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PRENATAL DEVELOPMENT OF SNOWSHOE HARES[1]

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ABSTRACT

In independent but closely parallel studies, prenatal showshoe hares of known age were collected from wild-trapped stock bred in captivity in New York and Michigan. Data from the two sources were combined to derive growth curves and criteria for determining the age of embryos. Weights, measurements and morphological characteristics were recorded for specimens 9 to 34 days in gestation age and for newborn young. Only data for healthy litters, distributed in both horns of the uterus and consisting of two to five embryos, were used to calculate second-degree least square polynomial curves and their 95 per cent confidence limits for both weight and length. Morphological characteristics are described for embryos 9, 10, 11, 12, 14, 16, 18, 20, 22, 24, 28, 30 and 34 days old.

The snowshoe hare (*Lepus americanus*) is an important part of the fauna of the northern United States, Canada and Alaska. It is generally found in the heavily forested areas of this region. In the more remote areas the species is underharvested, while in the more accessible areas the degree of potential exploitation by hunting is unknown.

If the weight, size and external characteristics of unborn hares of known gestation age were available, the conception and parturition dates of pregnant hares obtained in the wild could be estimated. Examination of a large number of pregnant hares collected over an entire breeding season may reveal definite peaks in the dates of conception and parturition and indicate the percentage of breeding females with second, third or more litters. Such information would contribute to a better knowledge of the total annual productivity of snowshoe hares.

The prenatal development of snowshoe hares was described by Dell (unpublished) and Bookout (1964). The objective of this paper is to

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combine the data from these two sources to provide growth curves and criteria which will permit accurate aging of embryos.

METHODS

Although the two studies were planned and executed separately, most of the techniques and operations were identical or very similar. None of the differences was deemed of sufficient importance to bias the combined data used to derive the growth curves and morphological descriptions.

In New York, adult snowshoe hares were purchased in Maine in 1941 and shipped to the Delmar Game Farm for the primary purpose of producing young for restocking. Embryo collection was undertaken as a sub-study in recognition that an ability to back-date embryos to determine conception dates would be a valuable aid in determining breeding phenology in wild hare populations.

Hares were held in individual pens (3 x 8 x 2 feet) with sides of 1-inch-mesh chicken wire fencing. The floor was half-inch-mesh woven wire fencing. Four individual pens with an enclosed common wire runway (1 foot wide) between them was considered a breeding unit. The entire breeding unit was elevated approxmiately 2 feet off the ground on 2 x 4-inch legs. Three females and one male were held in each unit. Access to the runway between the pens was by trap doors operated by the caretaker from outside the unit.

Breeding was achieved by driving the female into the runway and closing off access to her pen. Then the male's pen door was opened. They were kept under observation until they mated, then separated. If mating was not observed, the pair was brought together again 1 to 2 weeks later. After copulation occurred, the female was returned to her pen, and the date was noted on a breeding record tag attached to her pen. On the day of parturition (up to 15 hours could have elapsed between parturition and the time the young were discovered), the female and male were paired again and observed. In contrast to first matings, copulation usually was rapid following parturition. After copulation, the female was returned to her pen to attain the desired stage of gestation. Most of the embryos were obtained by sacrificing the female. Later in the study a few were obtained by Caesarian section. Specimens were obtained from females carrying their first litter of the season as well as from females carrying up to their fourth litter of the season.

In Michigan, wild snowshoe hares were box trapped in Alger and Schoolcraft Counties. All the captured hares were taken to the Cusino Wildlife Experiment Station, ear tagged for identification and confined in 3 x 3 x 4-foot hutches during the first two summers. In 1961 and 1962, they were permitted to remain on the ground in pens approximately 10 x 10 feet in area and constructed of 5-foot chicken wire fencing with ¾-inch mesh.

Attempts to breed nonpregnant females were made as soon as they were brought to the pens. Pregnant hares were watched closely until the young were born. On the day of parturition (up to 15 hours could have elapsed between parturition and the time the young were discovered), the females were introduced into a breeding pen containing a male hare. This pen was a rectangle approximately 5 x 10 feet in area, large enough to ensure that breeding activity, particularly the chase, was not interfered with and small enough to prevent the male being eluded by the female. Careful watch was kept of the activities of the hares, and any breeding phenomena were recorded.

In both studies, after copulation occurred the female was returned to her pen and palpated every few days to determine pregnancy, which could not, however, be done with certainty until the tenth day of gestation. The pregnant hare was returned to her pen to attain the desired stage of gestation for collection of embryos. If not pregnant, she was reintroduced into the breeding pen periodically until copulation again occurred and then held until the desired day of gestation.

Pregnant hares were sacrificed at various days of gestation. The number of embryos in each horn of the uterus was noted, and each intact individual was weighed and measured. Embryos less than 9 days old were too small for gross weights and measurements. Specimens of 9 to 18 days gestation were weighed to the nearest 0.01 gram, older ones to the nearest 0.1 gram. Crown to rump and forehead to rump lengths were the standard body measurements recorded. Measurements for specimens of 9 to 18 days gestation were crown to rump; those for specimens of 19 days or more were forehead to rump. Ear and hind foot measurements were taken on the larger specimens. All weights and measurements were made as the embryo was taken from the uterus.

Litters of newborn hares that had completed a full gestation period of approximately 37 days (Severaid, 1945) were weighed and measured in the New York study only. These specimens were weighed to the nearest gram after the fur had dried, generally the morning following birth (up to 15 hours could have elapsed after parturition). These data were included for completeness. However, they were not used in calculating the growth curves because of the possibility that they would not be comparable with those for *in utero* specimens.

All the known-age specimens used in this study were preserved in 10 per cent formalin and stored at either the Wildlife Research Laboratory at Delmar, New York or the Museum of Zoology of the University of Michigan at Ann Arbor, Michigan.

Examination of the data indicated that the growth pattern, for both weight and length development, would be best depicted by a least square polynomial curve. To obtain values for such a curve and to determine its 95 per cent confidence limits, a General Electric Mark II computer was

used. A program (confinlm) that fits least square polynomials to bivariate data by an orthogonal polynomial method was used. The limits on this program were a fifth-degree fit and a maximum of 100 data points. This program allows the user to specify the lowest degree polynomial to be fitted and fits that polynomial in order of ascending degree. At each stage, the index of determination was printed. The closer this index is to 1, the better the fit. A summary of the program was printed showing the calculated values of both the weight and the length measurements (y) for each day of gestation (x) and the 95 per cent confidence limits for the calculated values of y.

The most meaningful curve fit was obtained by converting the weight and length measurements to natural logarithms (done on a Wang calculator) and using them in the computer. The calculated values of y and the 95 per cent confidence limits obtained from the computer were then converted to numbers on the calculator. A second-degree polynomial gave an index of determination of 0.987 for both curves. The index for a first-degree polynominal was 0.941 and represented a poorer fit. The index for a third-degree polynomial (0.991) was a slight improvement, but the curve obtained was impractical. Therefore, the second-degree polynomial was used. These values were plotted on graph paper and a smooth curve was drawn through the plotted points.

Measurements of 112 embryos were available for study. To reduce these data to the program limit of 100 data points, only litters of two to five embryos were used to calculate the growth curves. Litters of one and six embryos were discarded. Two additional litters that may have been atypical were also discarded. One was from a female that died with five embryos 25 days old. The embryos were small and one had an ulcer on the rump. The second consisted of four embryos, 36 days old, that were all small and in the same horn of the uterus. Accordingly, 90 embryos of known gestation age, from 29 litters, were used. Weights were available for only 73 of these. The youngest specimens were 9 days old, the oldest 34 days.

FINDINGS

The weights and lengths measurements recorded are given in Tables 1 and 2, respectively. Data were not available for each day of gestation, and the computer program provided calculated values for only the days for which data were available. These values were used in developing the growth curves (Figures 1 and 2). The calculated values are given in Tables 3 and 4 together with values estimated from the growth curves for days for which no data were available. All the data points fell within the confidence limits except those for the measurements of one litter of three 9-day-old embryos which were less than 3.3 millimeters long or the lower confidence limit for an embryo of this age.

Although the data for newborn hares were not used in the calcula-

TABLE 1. WEIGHTS OF 73 SNOWSHOE HARE EMBRYOS OF KNOWN GESTATION AGE AND OF 22 NEWBORN HARES

Gestation age (days)	Number	Weight (grams)*	
		Distribution§	Average
9	2	*0.01, 0.01*	0.01
10	2	*0.02, 0.02*	0.02
12	4	*0.12, 0.15, 0.15, 0.16*	0.15
14	6	0.27, 0.30, *0.30, 0.34, 0.36, 0.39*	0.33
16	2	0.50, 0.54	0.52
18	6	1.28, 1.30, 1.50, *1.53, 1.61, 1.64*	1.48
19	3	2.1, 2.1, 2.1	2.1
20	5	2.1, 2.2, 2.5, *2.9, 2.9*	2.5
21	3	3.5, 3.7, 3.7	3.6
22	6	*3.7, 4.4,* 4.7, *5.1,* 6.2, 7.1	5.2
24	2	*8.3, 8.4*	8.4
25	4	*11.5, 12.0, 12.2, 14.0*	12.4
27	4	12.4, 14.4, 14.8, 15.1	14.2
28	6	*18.3, 19.2, 19.5, 20.1, 20.5, 21.0*	19.8
29	4	*29.0, 29.1, 29.9, 31.7*	29.9
30	5	*37.3, 38.5,* 39.6, 41.4, 41.7	39.7
31	2	*41.7, 42.6*	42.2
34	7	64.0, 64.2, *64.7, 65.0,* 67.4, *67.9,* 69.9	66.2
Birth	22	64, 72, 72, 72, 74, 75, 75, 75, 78, 78, 82, 83, 84, 84, 86, 86, 88, 92, 92, 94, 95, 96	81.7

* Figures in italics are weights recorded for Michigan specimens by Bookout.
§ Weights of embryos 9 to 18 days old recorded to nearest 0.01 gram; those of embryos 19 to 34 days old recorded to nearest 0.1 gram. Data for newborn young are dry weights to nearest gram.

tions, the means are shown on the respective graphs for completeness. The weight of 22 newborn hares (at approximately 37 days of gestation) averaged 81.7 grams with a range of 64 to 96 grams. These data appear to fall within the confidence limits of the graph if the lines were projected. A similar situation existed with respect to length measurements; eight newborn hares averaged 105.3 millimeters with a range of 97.0 to 113.4 millimeters.

Based on these growth curves, the estimated age, together with the 95 per cent confidence limits (i.e., minimum and maximum age), for successive weight and length classes are given in Table 5. As the weight and length of embryos increased, the span of the age limits increased. For embryos weighing 0.5 gram, the estimate age was 9.4 to 12.0 days or a span of 2.6 days. For 15-gram embryos, the span was 4.2 days, and at 35 grams it was 6.5 days. The relationship was similar for length. For embryos 10 millimeters long, the estimated age was 11.8 to 14.3 days or a span of 2.5 days. For a 40-millimeter embryo, the span was 3.7 days, and at 70 millimeters it was 6.0 days.

Because snowshoe hare embryos grow rapidly, a description of their morphology at progressive stages will assist in estimating age, especially when there are marked measurement differences among individuals in the same litter. A series of known-age specimens is illustrated in Fig-

Table 2. Lengths of 90 Snowshoe Hare Embryos of Known Gestation Age and of Eight Newborn Young

Gestation age (days)	Number	Length (millimeters)*	
		Distribution§	Average
9	5	2.8, 2.8, 3.0, *3.5, 3.5*	3.1
10	2	*5.5, 5.5*	5.5
11	9	*6.0, 6.5,* 6.5, *7.0, 7.0,* 7.5, 8.0, 8.0, 8.0	7.2
12	4	*9.0, 9.0, 9.5, 9.5*	9.3
14	7	12.8, 12.8, *14.0, 14.0, 14.5, 14.5, 14.5*	13.9
16	2	17.0, 17.0	17.0
18	6	23.1, 24.0, 24.0, *25.0, 25.0, 25.5*	24.4
19	3	31.3, 31.8, 32.6	31.9
20	5	33.2, 34.0, 34.1, *35.0, 35.5*	34.4
21	3	41.0, 42.0, 42.0	41.7
22	6	*39.0, 39.5, 43.5,* 46.0, 48.7, 49.8	44.4
24	2	*44.0, 47.0*	45.5
25	8	60.0, *60.0, 61.0, 61.0, 61.0,* 62.0 63.5	61.3
27	4	63.8, 65.5, 68.3, 68.9	66.6
28	6	*66.0, 67.0, 67.0, 68.0, 68.5, 69.0*	67.6
29	4	*80.0, 82.0, 83.0, 8.40*	82.3
30	5	*91.0, 92.1,* 93.1 93.4, 95.8	93.1
31	2	*93.0, 95.0*	94.0
34	7	*104.0,* 105.2, 106.2, 110.2, 112.7, *113.0, 115.0*	109.5
Birth†	8	97.0, 98.0, 99.0, 104.0 107.8, 111.0, 112.5, 113.4	105.3

* Figures in italics are lengths recorded for Michigan specimens by Bookout.
§ Lengths of embryos 9 to 18 days old were crown to rump; those of embryos 19 to 34 days old and of newborn young were forehead to rump.
† Measurements at birth averaged less than for 34 days of gestation because specimens were not sacrificed and tended to stiffen when handled.

ure 3. Except as indicated, the descriptions that follow hold true for both the Michigan and New York specimens. Differences are undoubtedly accounted for by the fact that variations of several hours in actual age could have occurred among the specimens of any age group represented by two or more litters.

Nine Days The calculated means for these specimens were 0.02 gram in weight and 4.1 millimeters in length. The embryo was opaque and C-shaped. A clear area was present in the eye region and limb buds were present (in the Michigan specimens neither was discernible). The heart was external. The embryos exhibited torsion and flexion. These embryos were rather similiar in appearance to a 9-day-old domestic rabbit (*Oryctolagus cuniculus*) embryo as described by Minot and Taylor (1905).

Ten Days The calculated means for these specimens were 0.03 gram in weight and 5.3 millimeters in length. The embryo was C-shaped. A faint eye spot was present. Limb buds were formed (in the Michigan specimens none was discerned). The heart was external. The tail was free and pointed. Torsion was still present and specially noticeable in the tail. These embryos were similar in appearance to a 10-day-old domestic rabbit embryo as described by Minot and Taylor (1905).

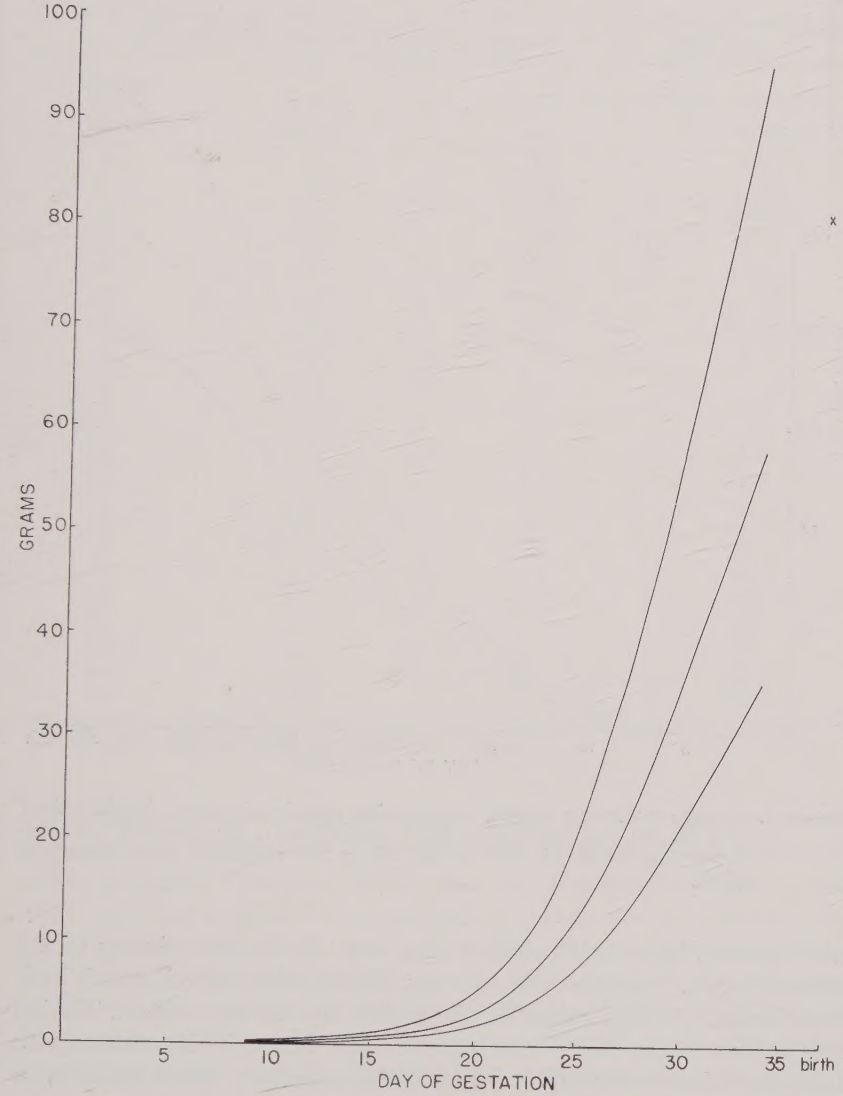


Figure 1. Growth curve for weight, representing calculated values (middle line) and 95 per cent confidence limits (outer lines), for snowshoe hare embryos from 9 to 34 days of gestation; "x" represents mean weight at birth.

ELEVEN DAYS The calculated means for these specimens were 0.05 gram in weight and 6.6 millimeters in length. The embryo was opaque and C-shaped, the nose being very close to the tail. The eye was easily recognized as a thin brown circle, transparent in the center. The mesencephalon protruded as a hump. The head area was distinct from the thorax by constriction. The mandibular, hyoid and post-oral arches

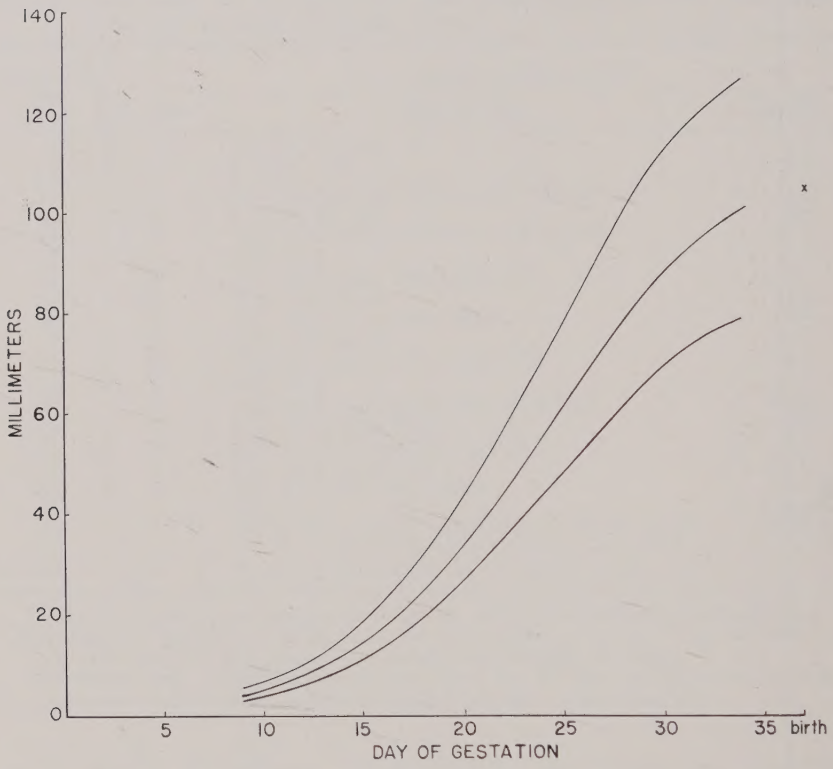


Figure 2. Growth curve for length, representing calculated values (middle line) and 95 per cent confidence limits (outer lines), for snowshoe hare embryos from 9 to 34 days of gestation; "x" represents mean length at birth.

were present. The paddle-shaped arm bud was located midway of the embryo length. The heart was external. Body somites and hind limb buds were distinct. A bulge indicating the genital tubercle was evident. Torsion was present in the tail. These embryos were similar in appearance to a 10½-day-old domestic rabbit embryo as described by Minot and Taylor (1905).

Twelve Days The calculated means for these specimens were 0.09 gram in weight and 8.2 millimeters in length. The embryo was curled in a tight C-shape. The eye spot contained pigment, and its color was decidedly different from that of the remainder of the body. The mesencephalon protruded as a hump. The external ear opening was not visible. The paddle-shaped limb buds were easily recognized. The body somites were distinct. Torsion was still present in the tail. These embryos were similar in appearance to an 11-day-old domestic rabbit embryo as described by Minot and Taylor (1905).

TABLE 3. CALCULATED WEIGHTS AND 95 PER CENT CONFIDENCE LIMITS FOR PRENATAL SNOWSHOE HARES ACCORDING TO GESTATION AGE

Gestation age (days)	Weight (grams)	95 per cent confidence limits	
		Low	High
9	0.02	0.01	0.03
10	0.03	0.02	0.06
11*	0.05	0.04	0.10
12	0.09	0.06	0.16
13*	0.16	0.10	0.26
14	0.24	0.15	0.40
15*	0.39	0.25	0.57
16	0.59	0.35	0.74
17*	0.90	0.50	1.45
18	1.31	0.79	2.17
19	1.9	1.1	3.2
20	2.7	1.6	4.5
21	3.8	2.3	6.3
22	5.2	3.2	8.7
23*	7.0	4.2	11.5
24	9.4	5.7	15.6
25	12.2	7.4	20.3
26*	15.2	9.2	26.5
27	19.7	11.9	32.6
28	24.3	14.6	40.3
29	29.4	17.8	48.8
30	35.0	21.1	58.0
31	40.9	24.7	67.7
32*	46.7	28.2	77.3
33*	52.5	31.7	86.9
34	58.3	35.2	96.6

* Weights estimated from growth curves (Figure 1).

FOURTEEN DAYS The calculated means for these specimens were 0.24 gram in weight and 12.4 millimeters in length. The embryo was curled in a tight C-shape. The eye spot was pigmented and quite noticeable. The mesencephalon was enlarged and protruded as a hump. The ear pinnae and openings were visible. The oral opening was present. The external nares were present as very shallow pits (in the Michigan Specimens they could not be discerned). Vibrissae follicles were apparent on the nose and over the eye. The elongated limbs showed differentiation between foot and leg. The foot was paddle-shaped with no digits apparent. Body torsion was no longer present. These embryos were similar in appearance to a 13-day-old domestic rabbit embryo as described by Minot and Taylor (1905).

SIXTEEN DAYS The calculated means for these specimens, were 0.59 grams in weight and 17.9 millimeters in length. The embryo was more fleshlike and less opaque than at 14 days. Although the embryo was still C-shaped, it was starting to elongate. The chin was tucked onto the chest. The mesencephalon was enlarged and protruded as a hump. The ear pinnae were enlarged, being 1.75 millimeters long. The vibrissae follicles on the nose appeared in five parallel rows between the oral opening

Table 4. Calculated Lengths and 95 Per Cent Confidence Limits For Prenatal Snowshoe Hares According to Gestation Age

Gestation age (days)	Length (millimeters)	95 per cent confidence limits	
		Low	High
9	4.1	3.3	5.3
10	5.3	4.1	6.7
11	6.6	5.2	8.4
12	8.2	6.5	10.4
13*	10.0	7.9	12.9
14	12.4	9.7	15.7
15*	15.0	11.5	18.9
16	17.9	14.1	22.8
17*	21.2	16.8	27.0
18	25.1	19.8	31.9
19	29.4	23.1	37.2
20	34.0	26.8	43.1
21	38.9	30.7	49.4
22	44.2	34.9	56.1
23*	49.7	39.3	63.2
24	55.5	43.8	70.5
25	61.4	48.4	77.9
26*	67.5	53.0	85.3
27	73.0	57.5	92.6
28	78.5	61.8	99.6
29	83.7	65.9	106.2
30	88.4	69.6	112.1
31	92.5	72.9	117.4
32*	96.0	75.2	120.8
33*	98.8	77.2	124.1
34	100.4	79.1	127.4

* Lengths estimated from growth curves (Figure 2).

and the eye spot. The eye pigment was distinct and formed a complete ring. The external nares were present. The feet were paddle-shaped with distinct toes that appeared "webbed". The hind foot and tail were too short to measure. There was a greater concentration of blood in the cardiac region than before. These embryos were similar in appearance to a 14- or 15-day-old domestic rabbit embryo as described by Minot and Taylor (1905).

Eighteen Days The calculated means for these specimens were 1.31 grams in weight and 25.1 millimeters in length. The embryo was straightening out with the chin held close to the chest. The mesencephalon appeared more as a prominent crest. The optic line separating the upper and lower eyelids was visible for approximately one-third the diameter of the eye. The sagittal and coronal sutures were evident. The toes on the feet were distinct. Hair follicles were apparent on the body. The heart prominence was no longer evident. The genital tubercle was evident. These embryos were similar in appearance to a 16- or 17-day-old domestic rabbit embryo as described by Minot and Taylor (1905).

Twenty Days The calculated means for these specimens were 2.7 grams in weight and 34.0 millimeters in length. The embryo was nearly

TABLE 5. ESTIMATED AGE AND 95 PER CENT CONFIDENCE LIMITS FOR SNOWSHOE HARE EMBRYOS ACCORDING TO WEIGHT AND LENGTH CLASSES

Weight class (grams)	Estimated age (days)	95 per cent confidence limits	Length class (millimeters)	Estimated age (days)	95 per cent confidence limits
0.5	10.6	+1.4 −1.2	10	13.0	+1.3 −1.2
1.0	17.3	+1.4 −1.2	20	16.7	+1.5 −1.4
5	21.8	+1.7 −1.5	30	19.2	+1.7 −1.6
10	24.3	+2.0 −1.7	40	21.3	+1.9 −1.8
15	25.8	+2.3 −1.9	50	23.1	+2.4 −2.0
20	27.1	+2.5 −2.3	60	24.7	+2.9 −2.2
25	28.1	+2.9 −2.4	70	26.5	+3.5 −2.5
30	29.1	+3.3 −2.5	80	28.3	+ * −3.0
35	30.0	+3.8 −2.7	90	30.4	+ * −3.7
40	30.9	+ * −3.0	100	33.8	+ * −5.5
45	31.7	+ * −3.2			
50	32.5	+ * −3.4			
55	33.4	+ * −3.7			

* Weights above 35.2 grams and lengths above 79.1 millimeters did not intercept the lower 95 per cent confidence limit of the curves.

straight. The head was round and smooth. The chin was close to the neck and chest. The optic line separating the upper and lower eyelids extended completely across the eye. The vibrissae patch on the nose was prominent. The ear pinnae were rolled anteriorly. Hair follicles were present on the cheeks, body and legs (none was noted in the Michigan specimens). The toes on the feet were prominent, soft nails being discernible on the digits. Blood vessels were evident under the skin. The external genitalia were prominent, and sex discrimination of the embryo was possible. The tail was approximately 3 millimeters long. These embryos were similar in appearance to an 18-day-old domestic rabbit embryo as described by Minot and Taylor (1905).

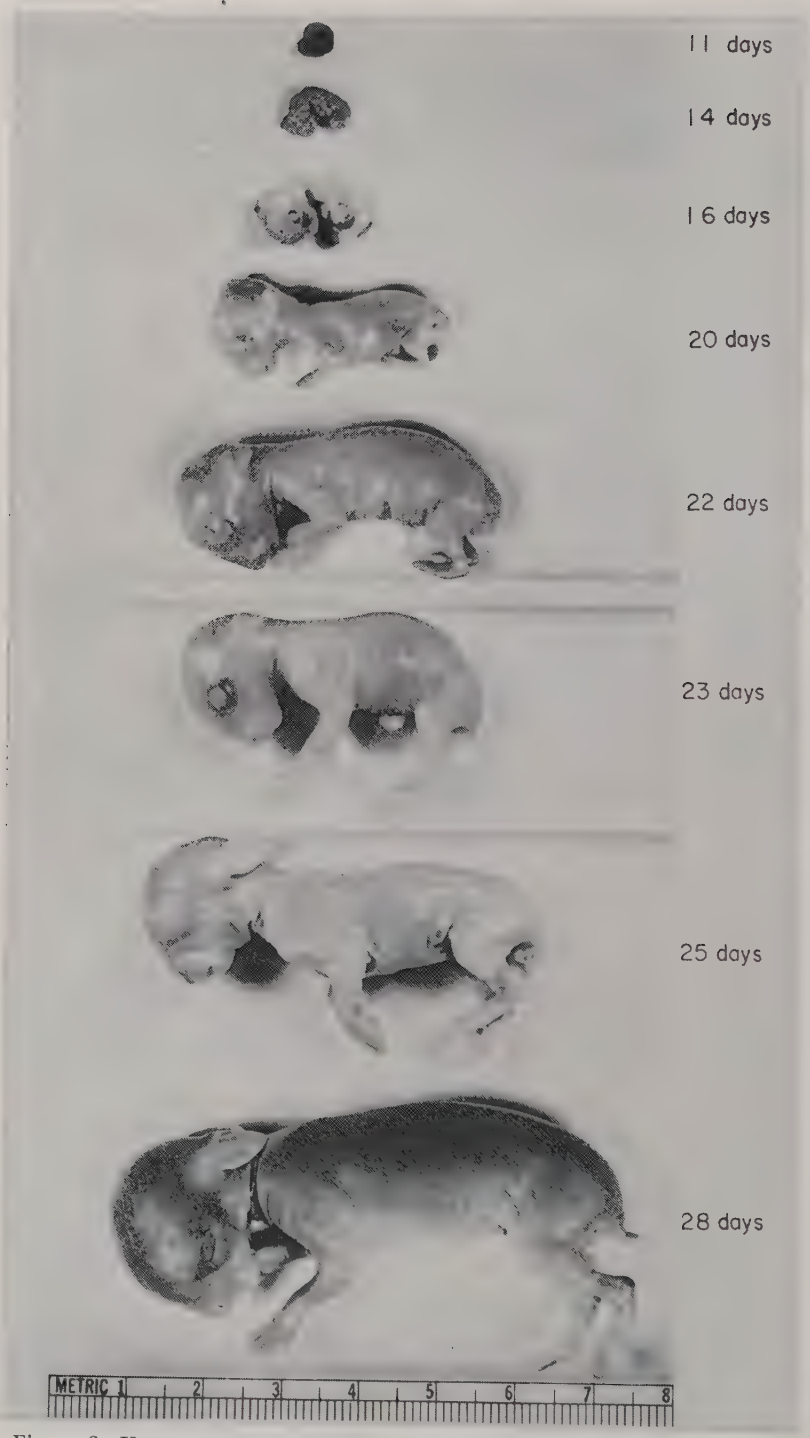
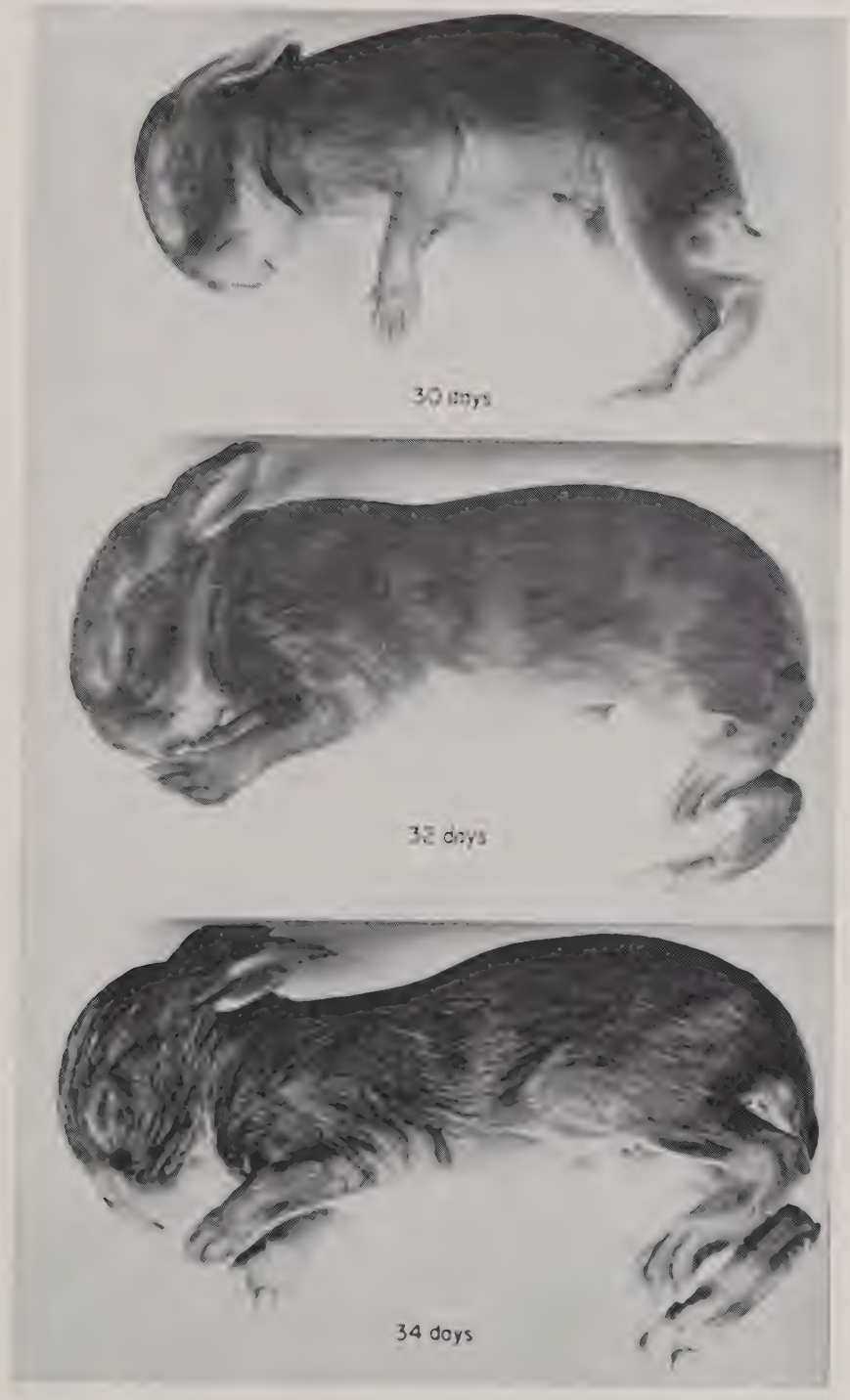


Figure 3. Known-age snowshoe hare embryos. Scale applies to all specimens, including opposite plate.


30 days
32 days
34 days

Twenty-two Days The calculated means for these specimens were 5.2 grams in weight and 44.2 millimeters in length. The embryos showed a general increase in size. (In the Michigan specimens, initial stages of pigmentation were noted with small blackish pinpoints or pigmented hair follicles being present on the top of the head anterior to the nape of the neck although none was present on the remainder of the body.) The ears extended posteriorly. The tail, approximately 3.5 millimeters long, was quite straight and pointed downward. The presence of interscapular fat deposits was the first indication of fat storage.

Twenty-four Days The calculated means for these specimens were 9.4 grams in weight and 55.5 millimeters in length. The embryos showed further increase in size and pigmentation. The latter extended over the head, back and lateral regions, but none was present on the underside. Very short vibrissae were evident on either side of the nostrils. Ear length had increased and averaged 5.5 millimeters from notch to tip of ear. The toenails were whitish and distinctly different in color from the feet. The teats were indistinct in both sexes. The tail was approximately 4 millimeters long and pointed downward.

Twenty-eight Days The calculated means for these specimens were 24.3 grams in weight and 78.5 millimeters in length. These embryos appeared dark with a bluish cast. A light covering of hair was present over the entire body. White hair was present on the underside of the body but was so sparse that the belly appeared naked. A white spot on the forehead was distinct. Ear length had increased and averaged 9.0 millimeters from notch to tip of ear. The eyelids could be separated with little difficulty. The teats were distinct in both sexes. The tops and bottoms of the feet were naked. The toenails were beginning to curve downward. The tail, approximately 5 millimeters long, was beginning to curl upwards.

Thirty Days The calculated means for these specimens were 35.0 grams in weight and 88.4 millimeters in length. These embryos appeared dark with brown on the body and white or pinkish on the underside. The entire body was covered with hair except for the inner ear tips, although hair was sparse on the ears, the ventral surface of the body, the top of the toes and the bottom of the feet. Ear length had increased and was approximately 13 millimeters from notch to tip of ear. The teats were very prominent. The tail was approximately 6 millimeters long.

Thirty-four Days The calculated means for these specimens were 58.3 grams in weight and 100.4 millimeters in length. These embryos appeared shaggy with long, dense pelage. The underside was distinctly white with the teats being obscured by the dense belly fur. The inner ear tips were well furred. The ears, the ventral surface of the body and the top of the toes were well furred. The bottom of the feet was lightly

Figure 4. One of litter of four small 36-day-old snowshoe hare embryos. Scale same as in Figure 3.

furred. Ear length was approximately 19 millimeters, and tail length was approximately 8 millimeters. All external characteristics appeared complete, and these embryos had the same appearance as term embryos. The eyes of one New York specimen were open.

THIRTY-SIX DAYS One litter of four 36-day-old embryos was observed in New York, one of which is shown in Figure 4. All were in one horn of the uterus and small; weights were 99.6, 101.3, 101.9 and 102.6 grams; lengths were 55.4, 57.6, 59.6 and 60.5 millimeters. The eyes of all these embryos were open. Specimens examined at parturition (approximately 37 days) differed only in weight and size.

DISCUSSION

The growth data for these curves were taken from known-age snowshoe hare embryos obtained from parents held in small pens. The adult hares were cared for daily, food and water being replenished as needed. Although these hares were all held under similar conditions, the number and size of the embryos varied between litters. Also, weight and length often varied considerably between individuals in the same litter. To reduce some of this variability in the data, only healthy litters, distributed in both horns of the uterus and containing two to five young, were used. Other factors that may have affected the number and size of the embryos in a litter include: age and weight of the parents; litter number (first, second, third, etc.) for the year; month of the year; available food; quality of food; and weather. In the wild, various stresses of living would also be involved. As the effect of these factors was unknown, the errors in aging due to them were assumed to fall within the confidence limits of the growth curves.

To estimate the age of a snowshoe hare litter: (1) weight and measure each embryo in the litter; (2) average the weights and length meas-

urements separately and estimate the age from the respective growth curves; (3) determine the mean between the two estimated ages and estimate the confidence limits, i.e., minimum and maximum age; (4) compare the embryos with the description of the age group nearest that mean, as well as the descriptions of all age groups within the estimated minimum and maximum age limits, especially those on either side of the mean; (5) estimate the age of the embryo from the descriptions; (6) using the estimates of age from the three sources (i.e., weight, length and description) calculate the average age and confidence limits. The actual age of the litter should fall within the confidence limits.

When this procedure was applied to data from known-age embryos that were not used in calculating the curves, the actual age of the litters fell within the confidence limits of the estimated age. The estimated age of a litter of one 11-day-old embryo was 10.8 days, or an error of 0.2 day. The estimated age of a litter of one 23-day-old embryo was 22.1 days, or an error of 0.9 day. For a litter of six 28-day-old embryos, the estimated age was 26.2 days, or an error of 1.8 days.

The lower limit of the present growth curves may be extended to zero, assuming that the pattern of ovulation and early pregnancy in the snowshoe hare is similar to that in the domestic rabbit as described by Hammond and Marshall (1925). They found that, in the rabbit, ovulation normally occurred 9½ to 10 hours following copulation, fertilization occurred in the fallopian tubes and the fertilized ovum did not reach the uterus until the fourth day when development exceeded the 16-cell stage. Thus, for most purposes, the fourth day may be considered the start of the growth curves.

The only data available for projecting the present growth curves from 34 days to birth were the weights and measurement of newborn young. But, as the effect of birth and drying on weight is unknown, projection of the weight curve was not feasible. Assuming that birth has no significant effect on the length of newborn hares, projection of the length curve might fall near or on the average for such specimens, but no data were available to project the confidence limits and projection of the curve on this assumption is not recommended.

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SPORT FISHERIES AND OFFSHORE OIL[1]

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ABSTRACT

The possibility of exploratory and production drilling for petroleum on the Continental Shelf off the Northeast Coast of the United States has aroused the concern of sportfishermen from New York and neighboring states. This paper discusses the marine sportfishery resources in the area in relation to the suspected petroleum reserves.

Recreational fishing in the Atlantic Ocean off the Northeast Coast has been important for more than a century. Westman (1939) stated "It is not known when party-boat fishing first started on Long Island, but records date back to the last decade of the eighteenth century when we learn that President Washington made a fishing excursion from Long Island to the banks off Sandy Hook." No mention is made as to whether or not he caught anything. Westman further explained that the earliest party boat fishing probably had its beginning when some commercial fishermen realized they could make money by taking out persons for sport fishing. This sort of marine activity soon became an important part of the Island's economic base.

The early economy of Long Island primarily had been dependent on agriculture, whaling and commercial marine fisheries. With the growth of the large urban centers, more and more individuals turned to angling in the sea for their recreation. One of the biggest boons to recreational fishing on Long Island was the development of the Long Island Railroad and, later, a system of paved roads linking all parts of the Island with the urban centers. This made it easier for the fishermen to travel to the ports that catered to anglers. As the number of sport fishermen increased, the boats and other facilities to accommodate them also increased.

The population of saltwater anglers has boomed since World War II but, except for local surveys, we had no idea of their numbers or their catch. Publication of the saltwater angling surveys of 1960, 1965 and 1970 (Clark, 1962; Deuel and Clark, 1968; Deuel, 1973) finally gave fishery managers a good look at the size of the angler population and its harvests of marine fishes. It was quite revealing. The anglers numbered in the millions of persons and the catches of some 79 species in the mil-

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lions of pounds. For many species, the recreational catch is equal to, or exceeds by a factor of four or five, the commercial catch. The size and extent of saltwater angling is a logical development. As David Wallace (1971) pointed out, "With such a variety of fish and such extensive coastlines, it is not surprising that so many million Americans wet their lines in angling on coastal waters."

It has become quite apparent that sportfishing is big business and in some areas is the commercial lifeblood of many communities. The "National Survey of Fishing and Hunting, 1970" (U.S. Bureau of Sport Fisheries and Wildlife, 1972) reported that, on all coasts of the United States, 9.5 million saltwater anglers invested $1.2 billion in the pursuit of their sport. Fifty per cent of these totals accrued to the Atlantic Coast.

We can expect that the numbers of anglers will continue to increase in the coming years. More leisure time, and more money to spend to fill the leisure hours, are directing more Americans to the ocean for fishing. In New York State alone, Alperin (1966) estimated that each year more than one million anglers fish the marine waters and that the numbers increase by 6 per cent annually. It is no wonder, then, that anglers, fishery managers and resource decision-makers express a keen concern for preserving the high quality of the marine waters to thus insure their continuing productivity.

It is my intention here to examine the sport fisheries of part of the Atlantic Coast in relation to offshore petroleum operations. The discussion will be confined to the area from Maine to Cape Hatteras, North Carolina—the North Atlantic and Middle Atlantic regions of the saltwater angling surveys.

SIZE AND VALUE OF THE MARINE SPORT FISHERIES OFF THE NORTHEAST COAST

The survey regions considered here constitute two distinct marine ecosystems. The North Atlantic Region includes the waters from Maine through New York; the Middle Atlantic Region includes New Jersey to Cape Hatteras. The growth in numbers of anglers was different in the two regions (Table 1). From 1960 to 1965, the number of anglers increased dramatically in the North Atlantic Region whereas it increased only slightly in the Middle Atlantic Region. However, the reverse was true from 1965 to 1970. Thus, in 1970, a total of 3.4 million saltwater anglers fished in the two regions and they caught 513.7 million pounds of fish. (For comparison, the 1970 commercial catch from these regions was 1,323 million pounds.)

It is estimated that each saltwater angler spent an average of $129 annually for such things as tackle, bait, food, lodging, boat rentals and so forth. Thus, the anglers who fished off the Northeast Coast in 1970 contributed $438.6 million to the local economy of the states from which

TABLE 1 NUMBER OF ANGLERS AND POUNDS OF FISH (BOTH IN THOUSANDS) CAUGHT IN THE SPORT FISHERIES OFF THE NORTHEAST COAST IN 1960, 1965 AND 1970

Region	1960	1965	1970
North Atlantic			
Number of anglers	1,160	1,530	1,666
Pounds of fish	183,740	316,360	267,451
Middle Atlantic			
Number of anglers	1,344	1,375	1,767
Pounds of fish	178,000	128,288	246,267
Total			
Number of anglers	2,504	2,905	3,433
Pounds of fish	361,740	444,648	513,718

they fished. In addition, their catches could be considered as having a dollar value as food. If we assume an average as-caught retail value of 50¢ per pound, the sportfish catch was worth $256.9 million.

LOCATION OF THE FISHERIES

As might be expected, saltwater anglers fish anywhere they have access to the sea. On the shore they fish from beaches, banks, piers and jetties. On the water they fish from rowboats, skiffs, self-owned cruisers, charter boats, and open or party boats. (The latter also are called "head" boats because the anglers pay a per-capita fee—usually about $10 to $15—for a one-day fishing trip.) The larger vessels often go well offshore to popular fishing grounds including the edge of the Continental Shelf near the Hudson Canyon. The data in the 1970 saltwater angling survey (Deuel, 1973) indicate that 33 per cent of the anglers fished from shore and 67 per cent fished from boats. Nearly half of them (44 per cent) fished in the ocean, whereas the rest fished in sounds, rivers and bays.

The coastal and offshore grounds exploited by the sport fishermen (Table 2, Figure 1) include many that formerly were exploited by handline and line-trawl commercial fishermen before the introduction of the otter trawl. The bottom usually is too rough for trawling but the grounds continue to yield large catches of a variety of species to the angler. The sport fishes of the area and their scientific names are listed in Table 3.

One such ground that is most familiar to me is Cox Ledge which is about 30 miles east of Montauk Point, N. Y., in approximately 20 fathoms. It is visited nearly year-round by a fleet of party boats from southern New England and Montauk, some of them carrying as many as 60 anglers. The largest vessels are up to 104 feet long and provide bunks, snack bars and other comforts for their customers. (The Cox Ledge fishery has been described in detail in Jensen, 1972.) The principal species sought is the Atlantic cod, but the anglers also catch white hake,

Table 2. Some Major Coastal and Offshore Grounds Fished by Saltwater Anglers in the Northeast

Name*	Shore reference	Principal species sought
(1) Jeffreys Ledge	25 miles east of Portsmouth, N.H.	cod, haddock, cusk, halibut
(2) Cashes Ledge	75 miles east of Portsmouth, N.H.	cod, haddock, cusk
(3) Stellwagen Bank	30 miles east of Boston, Mass.	tuna
(4) Chatham Grounds	15 miles southeast of Chatham, Mass.	cod, haddock
(5) Nantucket Shoals	35 miles southeast of Nantucket, Mass.	swordfish, marlin
(6) Cox Ledge	30 miles east of Montauk, N. Y.	cod, white hake, pollock
(7) Block Island	12 miles eastnortheast of Montauk, N.Y.	sea bass, scup, tautog, cod
(8) Montauk Point	2 miles east of Montauk, N.Y.	striped bass, bluefish
(9) Cartwright	4+ miles south of Montauk, N.Y.	large sharks, swordfish, marlin, tuna, sea bass, cod
(10) Southeast Grounds	5 miles southeast of Jones Inlet, N.Y.	cod, summer flounder, red hake, silver hake, sea bass
(11) Cholera Bank	10 miles south of Jones Inlet, N.Y.	albacore, tautog, bluefish, cod, dolphin, red hake, mackerel, pollock, scup, sea bass, silver hake
(12) McAllister Grounds	4 miles southeast of East Rockaway Inlet, N.Y.	cod, summer flounder, red hake, scup, sea bass
(13) Lightship Ridge	8 miles southeast of Rockaway Inlet, N.Y.	tautog, bluefish, summer flounder, red hake, scup, sea bass
(14) Acid waters	14–16 miles southeast of Rockaway Inlet, N.Y.	bluefish
(15) Hudson Canyon	90 miles southeast of New York, N.Y.	tilefish
(16) The farms	8 miles east of Monmouth Beach, N.J.	cod, bluefish, tuna
(17) Shrewsbury Rocks	4 miles east of Monmouth Beach, N.J.	bluefish, sea bass
(18) Mud Hole	10 miles east of Elberon, N.J.	bluefish, tuna

* Numbers in parentheses refer to location as shown in Figure 1.

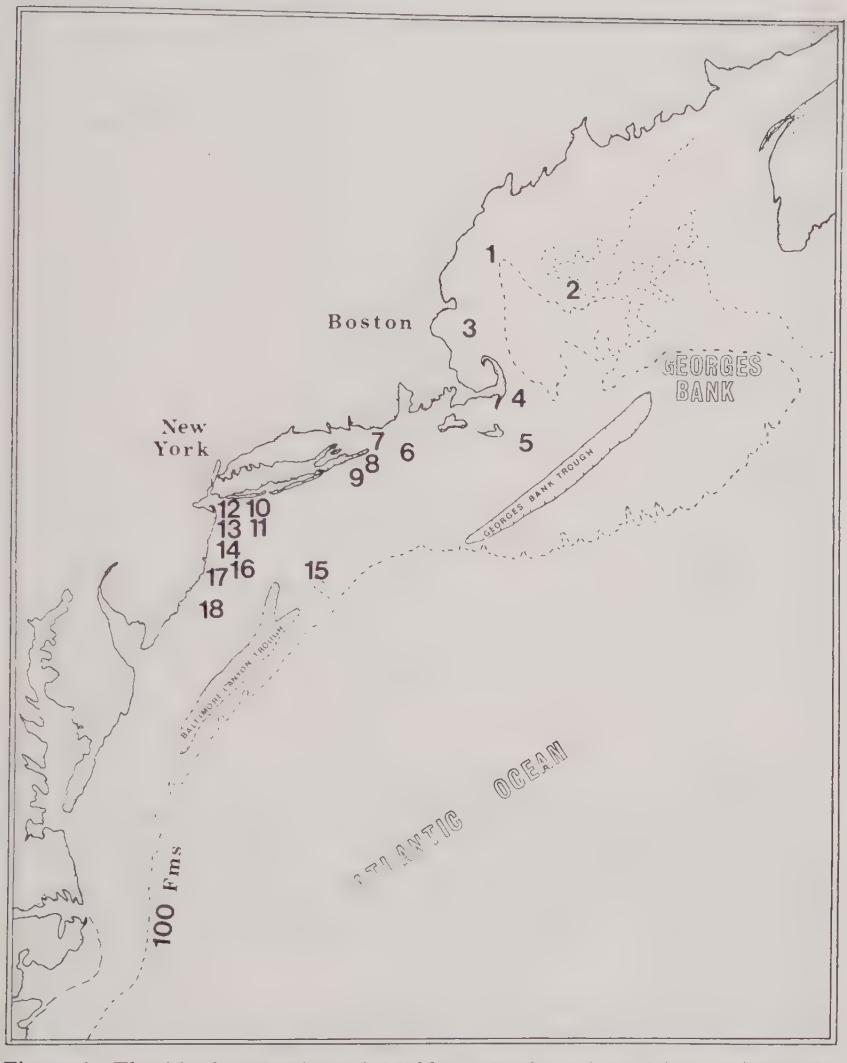

Figure 1. The North Atlantic and Middle Atlantic regions. The numbers refer to the fishing grounds as listed in Table 2.

pollock, haddock and an occasional halibut. Many of the cod and hake exceed 50 pounds each. Based on personal experience in fishing on this ledge, and from reports of the vessel captains and other anglers, I estimated that the catch-per-day of cod on a typical Montauk party boat is about 5,000 to 10,000 pounds. The annual sport fish catch of cod in the port of Montauk is about 6 million pounds.

The volume of the catch by recreational fishermen is surprisingly large, even if the various errors that enter into the collection and analysis of the data are taken into account. (Deuel, 1973). Table 4 lists the seven

Table 3. Sport Fishes of the Northeast Coast*

Common name	Scientific name
Cusk	*Brosme brosme*
Atlantic cod	*Gadus morhua*
Haddock	*Melanogrammus aeglefinis*
Silver hake	*Merluccius bilinearis*
Pollock	*Pollachius virens*
Red hake	*Urophycis chuss*
White hake	*Urophycis tenuis*
Striped bass	*Morone saxatilis*
Black sea bass	*Centropristis striata*
Tilefish	*Lopholatilus chamaeleonticeps*
Bluefish	*Pomatomus saltatrix*
Dolphin	*Coryphaena hippurus*
Scup	*Stenotomus chrysops*
Weakfish	*Cynoscion regalis*
Spot	*Leiostomus xanthurus*
Tautog	*Tautoga onitis*
Atlantic mackerel	*Scomber scombrus*
Albacore	*Thunnus alalunga*
Tuna	*Thunnus* spp.
Swordfish	*Xiphius gladius*
White marlin	*Tetrapurus albidus*
Summer flounder	*Paralichthys dentatus*
Atlantic halibut	*Hippoglossus hippoglossus*
Winter flounder	*Pseudopleuronectes americanus*
Northern puffer	*Sphoeroides maculatus*

* Nomenclature according to Bailey (1970).

Table 4. Estimated Weights of Seven Species Caught by Saltwater Anglers in 1970 According to Deuel (1973)

North Atlantic Region		Middle Atlantic Region	
Species	Weight*	Species	Weight*
Bluefish	50,161	Bluefish	49,720
Striped bass	45,844	Atlantic mackerel	29,250
Atlantic mackerel	41,482	Striped bass	27,262
Atlantic cod	35,688	Spot	21,573
Winter flounder	24,684	Puffer	16,568
Tautog	15,629	Weakfish	14,039
Summer flounder	11,611	Winter flounder	12,881

* Thousands of pounds.

Table 5. Comparative Catches (in millions of pounds) of Four Species by Recreational and Commercial Fishermen in the North Atlantic Region in 1970

Species	Recreational	Commercial
Bluefish	50.2	1.6
Striped Bass	45.8	1.4
Atlantic cod	35.7	37.2
Winter flounder	24.7	20.2

species that were caught in greatest volume in the North Atlantic and Middle Atlantic regions. The importance of these catches in terms of resource harvest can be determined by comparing the recreational catch with the commercial catch for some of the same species in the same area and in the same year. For the North Atlantic Region in 1970, the comparisons are shown in Table 5.

OFFSHORE OIL AS A POSSIBLE HAZARD TO SPORT FISHERIES

Seismic surveys and other geologic data indicate a number of areas off the East Coast that might prove to be sources of petroleum. Maher (1971) reported ". . . the Bahama platform, the seaward extension of the Cape Fear arch, the long basement ridge at the edge of the Continental Shelf off New England, and the Southeast Georgia embayment appear . . . to be the areas most favorable for initial operations in waters controlled by the United States." Two sites are of particular interest off the Northeast Coast. One is the Baltimore Canyon Trough which is parallel to the edge of the Continental Shelf for about 150 miles from approximately 40° N to about 38° N. The other is the Georges Bank Trough which is adjacent to the southeastern edge of Georges Bank, one of the most productive fishing banks in the world. This trough is about 215 miles long and in some places it is 25 to 30 miles wide.

Assuming that these troughs are indeed sources of petroleum, how long would it be before they are exploited? Dr. Thomas A. Grigalunas (1973) of the University of Rhode Island stated that 5 years is required from the time of the first lease sale to the start of production. He said "Assuming the jurisdictional dispute [Maine, *et al.*, vs. United States, re sea bed] currently before the Supreme Court is settled within the next several months, and assuming no further delays are encountered, it would be 1979 before actual production could begin." But, he continued, "we can anticipate delays and so production probably will not being until the early 1980's."

Reaction to the prospect of the extraction of offshore oil in the Northeast has been very marked. Resource agencies, citizen groups and fishermen have stated loud and long that they fear "another Santa Barbara" and damage to the marine resources. Damage is expected to occur from spills at both the drilling sites and the shoreside facilities. Rogers et al. (1973) reported that ". . . . the kind of geologic hazards that contributed to the Santa Barbara Channel oil spill may not be present along the East Coast, and the probable causes of oil spills, should this become a petroleum province, would be human erorr or equipment failure." There are other possible sources of spills because of the heavy traffic from otter trawlers that fish in the area. Many of the trawlers are very large, and they number in the hundreds representing some 16 nations (Jensen, 1971). For example, the area is particularly prone to dense fogs and se-

vere storms, and it is on the coastal hurricane track. A trawler could conceivably collide with one of the drilling platforms in spite of marker beacons on the platform and radar aboard the vessels. Pipelines from the platforms to shoreside facilities in places would be laid in soft, sandy substrate that shifts regularly in moving waves with the strong ocean currents. Exposed pipelines would be vulnerable to damage from the heavy otter boards (weighing upwards of 1 ton each) dragged by the trawlers as they fish.

The effects of oil on marine organisms was discussed by Dr. R. Nadeau of the Environmental Protection Agency at a seminar on oil spill prevention sponsored by the Regional Marine Resources Council and the U. S. Coast Guard on August 27, 1973 at Hauppauge, N. Y. He reported that biological damage from spilled oil would depend on:

1. Type and quantity of oil.
2. Hydrography of the area of the spill.
3. Season and climate.
4. Indigenous biota and their sensitivity.
5. Cleanup treatment used.
6. Previous exposure to oil spills.

The biological effects would vary from species to species and also with the life stage of each species, i.e., eggs, larvae, juveniles and adults. The most catastrophic damage would come with direct kill of organisms of all kinds and sizes by coating with oil and subsequent asphyxiation, by contact poisoning and by exposure to water-soluble toxic compounds. Selective damage would come with destruction of sensitive juvenile stages and the food organisms on which the biota depend. Long-term damage would come with the incorporation of sublethal amounts of toxic hydrocarbons which serve to reduce the animals' resistance to infection and stress.

The biological effects of an oil spill could be quite serious off the Northeast Coast because of the productive fisheries in the area. In addition to the adult forms of fishes that are found there, the area also is the spawning and nursery area for most of them (Perlmutter, 1939; Bigelow and Schroeder, 1953). Some of the species are demersal spawners, but their eggs and larvae are pelagic. With other species, the larvae, at least, are found at all depths, from the surface down. Thus, the early stages as well as the adults are vulnerable to environmental contaminants throughout the water column.

It is well also to consider the effect of spilled oil on the marine wetlands that border the shoreline along the Northeast Coast. These wetlands are the spawning and nursery areas for approximately 60 per cent of the fishes of interest to the saltwater angler. Experience from oil spills

near West Falmouth, Mass. in 1969 and in Long Island Sound off Northport, N. Y. in 1973 shows that there are three main effects. The initial flow of oil smothers and kills wetland plants and animals. The heavier fractions settle out and some are absorbed by the substrate. The oil that flows onto the peaty substrate of the wetland is absorbed. Some of the oil in the underwater substrate is ingested by claims and other sedentary animals. Some of the oil in both the underwater substrate and the peat substrate leaches out and represents a continuous source of oil contamination for an unknown (but probably lengthy) period of time. The indigenous plants and animals may be unable to recolonize the affected wetlands for a considerable interval.

An offshore oil spill could also directly affect the saltwater angler as well as the fishes he seeks. An example of this was widely publicized in the summer of 1971 (Keating, 1971) when a party boat out of Montauk, N. Y. was surrounded by an oil slick of unknown origin during a codfishing trip. The vessel, *Peconic Queen II,* was anchored on the southwest part of Cox Ledge while its customers fished. Suddenly, wrote Keating, "heavy, viscous oil fouled fishing lines and anchor cables, smeared the boat hull, and thoroughly greased the cod that the fishermen pulled up through the mess." As the fishermen pulled in their lines, the oil coated the rods and reels and smeared their hands and clothes. The oil is believed to have come from the illegally discharged ballast of a passing tanker. However, anglers fear that offshore oil production with the attendant possible spills would mean many duplications of the *Peconic Queen II* incident.

The East Coast has had many spills of various kinds of oil in various quantities, but it has never experienced spills from offshore oil facilities. Thus, much of the discussion, fear and opinion has been based on conjecture in interpreting the events either in the Gulf of Mexico or off the West Coast.

Although the research of Dr. Max Blumer and his associates at the Woods Hole Oceanographic Institution has given us some data, there is neither long-term experience with spilled oil nor extensive studies such as those in the Santa Barbara, Calif. area. Some scientists and environmentalists have attempted to use the Santa Barbara experience as a yardstick against which to measure the posible effects of a spill off the Northeast Coast. This can be dangerous. The Pacific Coast ecosystem in the Santa Barbara Channel is so different from anything off the Northeast Coast that such comparisons may be meaningless. Furthermore, some of the published reports of studies in the Santa Barbara Channel have tended to be contradictory. For example, Strachan (1972) reported:

> "There was some initial damage to certain algae and a surf grass on the Channel Islands, but later surveys revealed that these plants had

recovered. The invertebrates generally appeared to have remained healthy and viable. Our surveys indicated that all the fish observed were free from oil, and showed no signs of starvation due to oil on the plants and animals in their food chain.

"Speciation diversity appeared to have remained the same as before the oil leak. During our diving survey, we found no indication that there had been any modification in the number of species present."

Fauchald (1972), in the same area, reported adverse changes in the marine benthos, but he speculated that the changes may have been due to natural fluctuations, although he considered this "rather unlikely." He further suggested that additional studies are needed, and Nicholson (1972) suggested that long-term environmental changes may have favored instability among marine algal populations off Santa Barbara. She observed the following effects of crude oil: (1) barnacles that settled on weathered patches of oil were washed away when their substratum eroded away after further weathering; (2) sessile organisms (algal films and barnacles) were smothered by discontinuous patches of oil; (3) oil adhered selectively in the upper intertidal rather than in the lower intertidal due to greater length of exposure and consequent warming and drying of the former; (4) chronic presence of oil [as at Coal Oil Point near Santa Barbara] in the intertidal produces a beach with fewer plant species, but those that can tolerate or evade the effects of crude oil are abundant.

To gain some idea of what might result from offshore oil production on Georges Bank, a study was implemented by the Massachusetts Institute of Technology (Offshore Oil Task Group, 1973). The results of the study were reported in three volumes under the title, "The Georges Bank Petroleum Study", Volume II of which considered some of the problems I have discussed earlier. The study indicated, for example, that chances of an oil spill on Georges Bank reaching the Northeast Coast were nil in the fall and winter and about 5 per cent in the spring and summer. A system for collecting and containing a spill on Georges Bank would be at best marginally effective and sometimes completely ineffective. Less than 1 per cent of a year-class of cod or haddock would be killed by a spill in a spawning area on Georges Bank, assuming that the larvae encountered the spilled oil.

COMMENTS BY SALTWATER ANGLERS

I made an informal survey of anglers in the North Atlantic Region to find out how they felt about offshore oil operations off the Northeast Coast. While my survey has no statistical validity since the sample was so small, nevertheless, it provides an indication of the feelings of about two dozen saltwater fishermen. (A review of the popular press catering

to saltwater anglers will generally support the comments reported here.) The comments are as expressed to me by the anglers.

The basic feeling of the saltwater anglers is distrust. They do not trust the petroleum industry, the government regulatory agencies or the fisheries scientists and managers. Some of the individual comments include:

1. Present-day technology does not have enough certainty to prevent oil spills, either ashore or at sea.
2. The Federal inspection procedures on offshore oil rigs are not trustworthy.
3. The petroleum industry has been too smug and "smooth" in its presentations to the public. The expensive advertisements in magazines and on television are designed to lull the public into a false sense of security. The track record of the petroleum industry gives the lie to the statements in the advertisements.
4. The oceans are polluted enough from a variety of substances. Why add more in the form of spilled oil?
5. Sportfishing around the offshore rigs may indeed be excellent. However, oil spilled from the rigs negates any advantages gained by improved sportfishing.
6. The offshore rigs merely serve to attract and concentrate fish. They do not increase the actual abundance of any species. If fish attractors are to be built, they might better be built as artificial fishing reefs without the inherent danger of spilled substances.

CONCLUSION

Marine fishes represent a valuable, renewable resource of known volume and value. This is in complete contrast to the nonrenewable petroleum resource of absolutely unknown volume and value. The living marine resource, under sound management, can return a recreation and dollar dividend to the citizens indefinitely. This philosophy was succinctly summed up by David Wallace (Wallace, 1971): "The supply of fish along the coast is not limitless. We must husband the resource so that it is maintained at a high level."

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NOTES ON THE HISTORY OF WILD CANIDS IN NEW YORK[1]

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ABSTRACT

Over the past half century, wild canids bearing a resemblance to coyotes have been encountered with increasing frequency in New York, particularly in the Adirondack region where there has become established a population of animals that fit the general description of the eastern coyote (*Canis latrans* var.).

Over the past half century, wild canids bearing a resemblance to coyotes have been encountered with increasing frequency in New York, particularly in the Adirondack region. They have also been referred to variously as coyotes, brush wolves or coydogs. Many of the early specimens examined proved to be hybrids. More recently, however, an animal has become established which fits the general description of that found in northern New England and designated the eastern coyote (*Canis latrans,* var.) by Silver and Silver (1969). The present paper summarizes the history of the recent occurrence of wild canids in the State.

Early records of animals of this sort in New York occurred in the 1920's. According to Seton (1929) Prof. A. B. Recknagel of Cornell University reported a coyote taken near Ithaca in Tompkins County about 1920, although it is noted that it possibly was an escaped captive. Bromley (1956) reported that the first coyote recorded in the St. Lawrence River area was shot by a hunter about 1925 in the Town of Belmont in Franklin County 12 or 14 miles south of the Canadian border. Alkon and Schierbaum (1961) noted that Dr. W. J. Hamilton, Jr. of Cornell University told them of three coyotes that had been taken in Tonawanda Swamp in Orleans County in 1926.

Bump (1940) listed two fragmentary records: one of "8 (?)" imported coyotes that escaped in Ontario County about 1928 and were "killed several years later"; the other of an unknown number that were introduced in Albany, Columbia, Franklin and Saratoga Counties about 1934 and "gradually disappeared". In the same account, he also noted that an unknown number of timber wolves, imported by local residents in southern Franklin County about 1930, escaped and "crossed with dogs; increasing slowly(?)".

Streever (1936a) described hunting coyotes in Saratoga County and noted that three skins and two skulls were sent to Dr. H. E. Anthony at the American Museum of Natural History. In another publication

[1]A contribution of Federal Aid in Fish and Wildlife Restoration Project W-89-R.

(Streever 1936b), he referred to two of them as a "he wolf" taken on March 9, 1936 and a female taken on April 9, 1936. He also stated that Anthony had replied regarding the first that "your animal is a coyote" and regarding the second that it was "considered to be a coyote". Later, Streever (1948) wrote more about these coyotes and conclued that they were "escaped animals brought here as pups by visitors in the West". Whatever their origin, the animals apparently did not persist in this area.

About the same time (1934–1936) coyote-like animals were reported in the northern Adirondacks, mainly in Franklin County, and a number were taken by game protectors of the Saranac Lake Division. Five were sent to Dr. Anthony. In a letter dated February 28, 1936 pertaining to these observations (Streever, 1936b), Anthony stated, in part:

> ". . . when specimens were received at this Museum and at the Biological Survey in Washington, they proved to be either feral dogs or coyotes. The coyotes arrived in the Adirondacks as escaped animals and did not come into the region under their own power. The dogs which seem to be predominating elements in the packs, are large animals, either police dogs, collies or shepherd types. Apparently the coyotes run with the dogs and the interesting point at issue is whether the two animals have crossed and there are now hybrids in the packs.
> "I have examined specimens which combine the characters of these two animals and the evidence seems to be best disposed of by assuming that we do have hybrids. An argument against this is the lack of adequate observations demonstrating that the two animals do cross. There seems to be no doubt that the escaped coyotes in the Eastern States, lacking their own kind to run with, take up with wild dogs, and this condition has been reported from several Eastern States."

Richard G. Van Gelder of the American Museum of Natural History (personal correspondence, 1970) listed the Museum's records for the specimens received from Streever and the game protectors. These are given in Table 1. Of the eight specimens, one was identified as a coyote and six as Adirondack hybrids.

It is of interest that, during these years, the wild canids taken were chiefly gray coyote-like animals. Streever (1936b) quoted from a letter from Ray Burmaster, district game protector of the Saranac Lake Division, concerning a wild canid taken in February of 1934 and identified as a dog by the U.S. Bureau of Biological Survey (a decision with which Dr. Anthony disagreed) as well as several animals killed and bountied in Franklin County later in the year. Burmaster wrote "It would seem to me that if these animals are wild dogs that we would find different color phases among them. No one ever has found one yet any other color except wolf-grey or red or roufus . . ." Furthermore, they were largely localized in a few heavily forested areas. Mongrel types, such as became numerous a decade later along the outskirts of the forest, were rare.

Young and Jackson (1951) traced the eastward expansion of the coyote's range north of the Great Lakes. From this and personal correspondence with Dr. C. H. D. Clarke, it is evident that coyotes were

Table 1. Records of American Museum of Natural History For Specimens of Wild Canids From New York Submitted by Fred Streever and Game Protectors of the Saranac Lake Division in the 1930's*

Museum No.	Name	Sex	Origin			Nature of specimen
			Date	Locality	Collector	
121095	*Canis* sp.	Female (yg.)	?	Wayville (Luther tree nursery)	F. Streever	Skull
121096	*Canis* sp.§	?	?	Wayville (Luther tree nursery)	F. Streever	Skin and skull
121097	*Canis* sp.§	Female	April 9, 1936	Ballston Spa	F. Streever	Skin and skull
99283	*Canis* sp.§	?	?	Adirondacks	N.Y.S. Cons. Dept.	Skull
99466	*Canis* sp.§	Male	April 22, 1935	Between Merrillsville and Loon Lake	N.Y.S. Cons. Dept.	?
99612	*Canis* sp.§	Male	August 1934	Adirondacks (near Chazy)	G. R. LaPlante	Skin and skull
99653	*Canis latrans thamnos*	Male	February 13, 1934	Belmont (Franklin County)	N.Y.S. Cons. Dept.	Skin and skull
99678	*Canis* sp.§	?	April 25, 1934	Saranac Lake	N.Y.S. Cons. Dept.	Skin and skull

* Records furnished by Richard G. Van Gelder.
§ Adirondack hybrid.

present along the northern side of the St. Lawrence River in Ontario after about 1935 and in Quebec by 1944. Thus it was possible for coyotes to reach New York by crossing the St. Lawrence.

In 1941, while working at Pine Camp (now Camp Drum) in Jefferson County, the author observed several empty cages and was told that some troops from Oklahoma and Texas had brought coyote mascots with them and that the animals had been liberated before the troops left for embarkation overseas. An officer reported that at least six coyotes had been released in this way. There were no reports of any of them being trapped or killed.

During the years from 1937 to 1940, the author travelled extensively during the winter through and in the vicinity of deer wintering areas in the central Adirondacks. Although he saw an occasional bobcat track and an abundance of porcupine tracks, he could find no fisher tracks or signs of coyotes.

By 1942 and 1943, however, wild hybrid canids were being shot and trapped in the Croghan-Harrisville-Degrasse area in northern Lewis County and southwestern St. Lawrence County. The author saw more than 10 of these. They were big animals weighing 35 to 50 pounds. The hair coloration varied from white through many darker colors to black. There was no consistent pattern to this coloration. Litter mates, animals caught at the same den site, had different colors and patterns. There was one conspicuous similarity in the reports of trappers and hunters; it was difficult to catch adult animals. It was also a firm belief of most individuals that these animals were living in winter near deer wintering areas.

There was a doe season in the Adirondacks in late October of 1943. Checking stations were operated at many locations during the entire season. Hunters brought in bobcats, but no wild canid or coyote-like animal was recorded.

The winter of 1943–44 was very severe for deer throughout the Adirondack region, and thousands died of starvation. Residents of the area were also concerned that many weakened deer were being killed by bobcats. That winter the author investigated more than 50 reports of bobcat-killed deer. But nowhere, except in the Croghan-Harrisville-Degrasse area, were wild canids being blamed for large-scale killing of deer.

The available information indicates that these wild canids spread southward and northeastward from the Croghan-Harrisville-Degrasse area. They were seen and killed along the periphery of the forest, but they were much slower in penetrating the interior. The coyote-like canids that were present in Franklin County and vicinity in the 1930's apparently had disappeared. By 1945, grayish-coated animals were being taken which strongly resembled coyotes in appearance and which obviously differed from the wild hybrids previously encountered.

Such a specimen was taken in 1945 in the Town of Pierrepont in St. Lawrence County and submitted by Game Protector H. H. Reed. The skull was later sent to the U.S. Bureau of Biological Survey, and the following is from the reply (dated September 13, 1945) from H. H. T. Jackson.

> "I have examined and compared very carefully the skull that you sent in for identification, and although it shows some characteristics that might indicate a possibility of coyote blood nevertheless it is from a domestic dog. It is unfortunate in this case that the skin is not available for study. The animal may have some of the general appearance of a wolf such as appear frequently in full-blood German shepherd dogs. This particular animal, however, was too small for a pure German shepherd and the cross may have been collie or even possibly coyote. From skull characters the animal was apparently a male."

A second specimen, shot September 5, 1945 in the Town of Croghan in Lewis County, was also submitted by Protector Reed and sent to the U.S. Bureau of Biological Survey. The following is from the reply (dated October 9, 1945) from H. H. T. Jackson.

> "We have your letter of October 4 and also the skull fragments. The specimen is much easier to identify than the one you previously sent in. It is without any doubt a domestic dog, possibly one that had gone feral. The depth of the ramus of the jaw and the heavy and curved canine throw out any possibility of the animal having coyote affinities."

Another specimen, from the Town of Rossie in St. Lawrence County, was submitted by Game Protector Horace G. Turner and sent to the U.S. Bureau of Biological Survey, and the following is from the reply (dated December 28, 1945) from H. H. T. Jackson.

> "The skull of a 'coyote-like mammal' mentioned in your letter of December 19 has arrived, and can be referred without doubt to the coyote, *Canis latrans*. I would not care to attempt a determination of the sub-species, but the specimen matches closely some of the skulls from the Rocky Mountain region (Wyoming and Colorado). The skull is being returned to you by parcel post. That will give you one coyote skull for comparative purposes. I am afraid, however, that for the specimens more difficult to identify that you will find a series of skulls necessary, and probably will find it necessary to send the specimen on to us anyway."

On January 21, 1946, two specimens were sent to Dr. W. J. Hamilton, Jr. at Cornell University. The first had been submitted by Game Protector Godfrey Regetz of Constableville, N.Y. and had been shot in late December of 1945 by Fred Wormwood in the Town of Greig in Lewis County. The second had been shot on December 25, 1945 by Kenneth Morrow in the Town of Colton in St. Lawrence County and was submitted by Protector Reed who wrote in an accompanying letter "Related unusual condition. This animal was run by a fox hound and after running for a while went in a hole in the ground and was shot by Morrow." No written identification of these specimens was received. However, in personal conversation, Hamilton identified them as "being of uncertain species, not true coyote, and not conspicuously dog".

Thus, five specimens, all having the grayish coat color resembling that

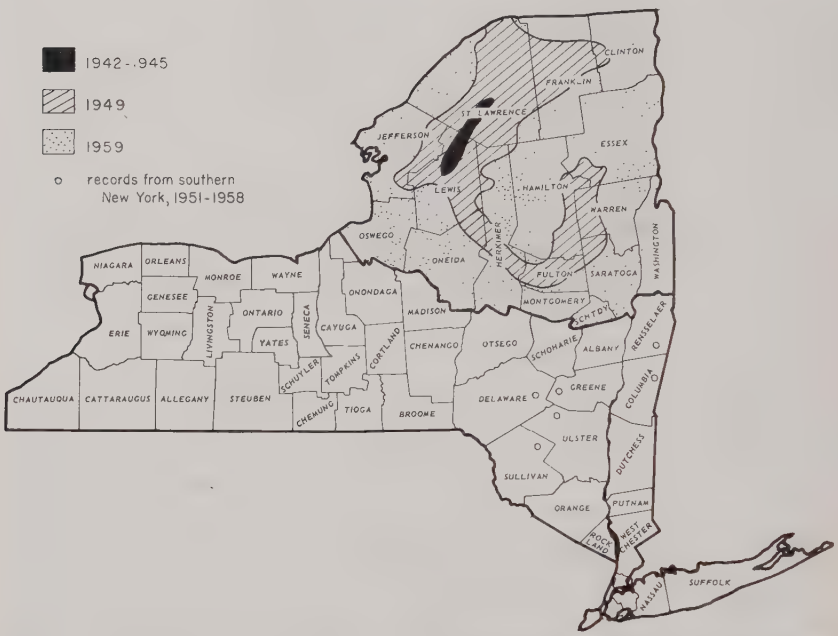

Figure 1. Progressive distribution of coyote-like wild canid in New York, 1942-1959. Southern boundary of area occupied by 1959 is arbitrary limit of northern New York.

of the coyote, had been examined by recognized mammalogists. Yet only one, from the Town of Rossie in St. Lawrence County, was identified as *Canis latrans*. It is important to note that these five animals had been selected, because they did appear to be coyotes, from hundreds of wild canids taken by hunters and trappers.

The winter of 1947–48 was severe for deer. Again, as in 1943–44, thousands died of starvation. There was one conspicuous contrast between the two years in the residents' concern for the deer. Because the "coydog" population had spread across most of the central Adirondacks, they were now concerned that the deer population would not survive the predation of both bobcats and wild canids in addition to starvation. This concern was widespread.

By 1950, the gray wild canids were present in most localities of the central Adirondacks and were being seen more frequently in the peripheral sections. The population was definitely extending its range. Its progressive distribution in the State is shown in Figure 1.

As these animals spread along the margin between the central and peripheral Adirondacks, it was observed that the first litters in a newly-occupied area were almost always obviously coydogs. George Buckley, caretaker at the DeBar Mountain Game Refuge in the Town of Duane in Franklin County, killed at least 10 young animals all of which had

mongrel coat colors and patterns, chiefly brown-white-black-gray mixtures. But he complained that he could not trap the "gray devils" and that when he saw them they were too far away to shoot. During the late 1940's, many wild canids were shot by deer hunters, who reported that the gray ones were very wild.

During the late 1940's and 1950's, hundreds of coydogs were seen at deer checking stations in the Adirondacks, and some were sent to the Wildlife Research Laboratory at Delmar (N.Y.). Unfortunately, these observations were incidental to other studies, and interest centered on the few specimens that exhibited strong coyote-like characteristics. No skulls or skins of the hybrids were preserved, and few photographs were taken. The Post Standard (Syracuse, N.Y.) for August 21, 1949 published a picture of five Adirondack "wolves" taken by Edward Maunton in the vicinity of Mountain View in Franklin County. The Knickerbocker News (Albany, N.Y.) for October 11, 1950 carried a picture of three animals, two considered to be coyotes and the third a hybrid. Another photograph, illustrating the variety of coloration in the same litter among such hybrids, is shown in Figure 2. These pups were taken at a den in the Town of Dickinson in Franklin County in 1958. The mother was seen at a distance and looked like a coyote.

Figure 2. Litter of coydog pups taken in Town of Dickinson in Franklin County (N.Y.) in 1958 showing variety of coloration that was typical among the hybrids that occurred in the northwestern Adirondacks during the 10 to 15 years following their appearance in the early 1940's.

During the 1950's, animals essentially coyote-like in appearance became predominant in the wild canid population in the Adirondacks. Two typical specimens were pictured by Streever (1953). In recent years, hybrids have become more and more infrequent.

Also during the 1950's, there were a few reports of hybrids outside the Adirondack region. The occurrence of a pack of coydogs in the Austerlitz Mountains in Columbia County was reported in the Chatham Courier (Chatham, N.Y.) for March 8, 1951. Alkon and Schierbaum (1961) reported three specimens taken in the Catskills in the summer of 1957 (at Roxbury in Delaware County, Lexington in Greene County and Neversink in Sullivan County) and one at Shandaken in Ulster County in 1958, as well as an apparently authentic report from Rensselaer County in 1958. Since then, wild canids have been found elsewhere in southern New York. (Also see addendum)

In summary, wild canids, living and reproducing as a wild population, were not known in New York prior to the 1940's. True, there were feral dogs, as well as household dogs that roamed a good deal but were harbored by people most of the time. It is known that some imported coyotes were released in the State and that in the 1930's and early 1940's the coyote extended its range eastward north of the Great Lakes into Ontario and Quebec from where it seems probable that animals crossed the St. Lawrence River into New York. In the 1940's and 1950's, a population of hybrids ("coydogs") developed in the northwestern peripheral Adirondacks and spread into the interior. Repeatedly, the mother of a coydog litter was reported to be a coyote-like animal. These were elusive, difficult to trap and difficult to hunt, whereas the more dog-like individuals were the ones usually taken by trappers and hunters. Gradually, the coydog-type animals largely disappeared and, by the late 1960's, especially in the central Adirondacks, there had become established a population of animals that fit the general description of the eastern coyote (*Canis latrans* var.).

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ADDENDUM

According to information provided the author (June 24, 1974) by Dr. Robert E. Chambers and Ward B. Stone, wild coyote-like canids have been identified from the counties of Broome, Cattaraugus, Cayuga, Cortland, Dutchess, Madison, Onondaga, Orange, Otsego, Putnam, Schoharie and Yates between 1971 and 1974.

NEW YORK'S FISHERIES FOR SCUP, SUMMER FLOUNDER AND BLACK SEA BASS[1]

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ABSTRACT

The reported commercial landings for New York's' marine fisheries show what appear to be serious declines in abundance. The heavy exploitation by foreign fishing fleets off our coast has been blamed for the declines. An examination of the data indicates that, for many species, the decline in commercial landings began well before the foreign fleets fished in the local coastal waters. Bilateral fishery agreements have been negotiated between the United States and the Union of Soviet Socialist Republics and the Polish Peoples Republic. Preparatory to the signing of these agreements, the Department of Environmental Conservation was requested to review New York's fisheries for scup, summer flounder and black sea bass. The results of the review indicate that the recreational fisheries are responsible for a substantial removal of the resource. It is suggested that as management plans are made for New York State's marine fisheries, serious consideration be given first to managing the recreational effort.

The heavy fishing pressure exerted by foreign fishing vesesls operating in international waters off New York's coast has been directed at a number of species of interest to the State's fishermen. The size and numbers of vessels involved and the volume of their catches (Jensen, 1971) made it necessary for the United States to enter into bilateral marine fishery conservation agreements with the Union of Soviet Socialist Republics (USSR) and the Polish People's Republic (Poland). In preparation for renewal of these agreements, fisheries administrators in the coastal states along the Middle Atlantic Bight (Cape Cod to Cape Hatteras) were requested to review their fisheries for certain designated species.

The present report was prepared in response to this request and reviews the fisheries for scup (*Stenotomus chrysops*), summer flounder (*Paralichthys dentatus*) and black sea bass (*Centropristis striata*) engaged in by New York State fishermen in the Middle Atlantic Bight. Most of the catches were made in New York waters and all were landed at New York ports.

THE FISHERIES

A recent, comprehensive review of the marine fisheries of New York

[1]Contribution No. 74-3 of the Division of Marine and Coastal Resources. The author thanks John C. Poole and Samuel L. Finkelstein for their assistance in supplying data.

State (McHugh, 1972) has documented the fluctuations in commercial landings and apparent abundance of a variety of species of shellfish and finfish. Most of the species have declined over the past century. Some of the declines may be the result of natural causes, others may be the result of overfishing. A further complicating factor is that most of the finfishes important in the commercial fishery are also important in the sport fishery. The 1970 survey of sport fishermen (Deuel, 1973) reported a recreational catch for many species which greatly exceeded the commercial catch. For example, in the North Atlantic Region (New England and New York), the recreational catch of summer flounder in 1970 was 10 times greater than the commercial catch. Thus, the heavy exploitation by sport fishermen should be included in any consideration of the possibility of overfishing.

SCUP

The scup traditionally has been one of the mainstays in New York State's commercial fisheries. Over the past 19 years (Table 1) land-

TABLE 1. LANDINGS (METRIC TONS) AND VALUE (THOUSAND DOLLARS) OF NEW YORK'S COMMERCIAL FISHERIES FOR SCUP, SUMMER FLOUNDER AND BLACK SEA BASS*

	Scup		Summer flounder		Black sea bass	
Year	Landings	Value	Landings	Value	Landings	Value
1972	590	442	455	439	20	16
1971	590	404	496	360	25	19
1970	455	349	408	356	32	24
1969	744	352	261	200	31	23
1968	1,271	629	552	396	30	23
1967	1,495	639	892	487	49	35
1966	1,856	637	1,121	586	101	59
1965	3,421	746	1,112	557	173	84
1964	3,790	783	843	445	227	95
1963	4,320	783	593	368	268	108
1962	4,870	743	722	363	238	101
1961	5,468	873	1,055	458	142	77
1960	5,890	767	1,139	514	238	99
1959	6,130	834	1,272	500	277	115
1958	6,300	907	1,064	458	382	130
1957	5,340	807	1,587	502	268	106
1956	4,930	721	1,900	747	232	65
1955	5,930	752	1,181	500	425	121
1954	5,829	726	1,672	630	573	170

* Source: "New York Landings".

ings have varied, reaching a high of more than 6.3 thousand tons[2] in 1958, following which they decined steadily to a low in 1970 of slightly more than 455 tons. In 1972 landings were 590 tons.

[2]Metric tons (=2200 pounds).

The scup also is important in the State's recreational fisheries. Briggs (1968) showed that for the years 1964, 1965 and 1966 it represented 27.8, 44.6 and 35.7 per cent, respectively, of the species composition of fish caught by anglers in the inshore waters of eastern Long Island. He also showed that the estimated catch was as high (in 1965) as one million scup (approximately 600 tons of fish). The 1970 recreational landings reported for the North Atlantic Region were 1.04 thousand tons (Deuel, 1973) and the commercial landings for the same region were 865 tons.

The life history of the scup in New York waters has been studied by Finkelstein (1969a, 1969b, 1971). He noted (1969a) that ". . . from historical times to the present [it] has exhibited extreme fluctuations, from periods of great abundance to periods of such scarcity that the species was virtually absent from our coast for years. . . ." Scup grow very rapidly during the first 5 years and can reach at least 15 years of age, based on the analysis of scale markings. New York State law sets a minimum size of 17.8 centimeters (7 inches) for scup in the commercial fishery. An examination of Finkelstein's data (1969a) suggests that such fish are approximately 2½ years old. Both males and females reach sexual maturity at about 2 years of age (Finkelstein, 1969b). Thus, the bulk of the fish landed in the commercial fishery would have spawned at least once.

A tagging study of scup collected in the inshore waters of eastern Long Island (Finkelstein, 1971) showed that most of the fish were taken by the commercial fishery. He tagged nearly 4,000 fish, of which 693 were recovered, 33 per cent being taken by recreational fishermen and more than 66 per cent by commercial fishermen. The tagged fish ranged extensively along the East Coast; recovery sites included Georges Bank (off Massachusetts) and along the coast to Nags Head, North Carolina. Analysis of the tag return data revealed that the average exploitation rate of scup tagged during the summer was approximately 15 per cent. The annual natural mortality rate was approximately 80 per cent, and the total mortality rate was approximately 95 per cent.

An approximation of catch-per-effort in the commercial fishery may be made from an examination of the landings at Fulton Market in New York City. These data are reported in "New York Landings", published by the National Marine Fisheries Service in cooperation with the State Department of Environmental Conservation, and are summarized in Table 2 for the years 1961 to 1971. The data show a decline in catch-per-trip by otter trawlers from 10.7 tons of scup in 1961 to 0.9 ton in 1970. The catch rose to 1.1 tons in 1971.

The reader is cautioned that the index of abundance data are only a very rough approximation. Nevertheless they serve to verify the de-

Table 2. Estimated Index of Abundance and Landings (metric tons) of Scup Landed at Fulton Market (New York City)

Year	Landings	Number of otter trawl trips	Catch per trip
1972*	..	..	..
1971	20	18	1.1
1970	13	15	0.9
1969	169	69	2.4
1968	416	114	3.6
1967	593	107	5.5
1966	474	61	7.8
1965	965	102	9.5
1964	1,368	176	7.8
1963	2,220	197	11.3
1962	2,915	255	11.4
1961	3,139	293	10.7

* Data not available.

cline in abundance and landings of scup in that part of the Middle Atlantic Bight fished by New York otter trawlers.

Summer Flounder

The decline in the abundance of summer flounder in the Middle Atlantic Bight is evidenced by the ups and downs (and a general decline) in the commercial and recreational landings for the species. The published New York landings (Table 1) show a high of 1.9 thousand tons in 1956. A low of 261 tons was landed in 1969, but the landings began to increase again, reaching slightly more than 455 tons in 1972. The 1970 recreational landings in the North Atlantic Region were 5.3 thousand tons (Deuel, 1973) and the commercial landings were 500 tons.

It seems clear that the decline in landings is the result of a decline in abundance of the species. Unfortunately, except for the reported landings, we do not have supporting evidence of this for the commercial fishery. There is, however, such evidence (Schaefer, 1966) for the recreational fishery in Great South Bay (Long Island, N. Y.).

This Department had received repeated reports in the early and mid-1950's of declining, in-season catches and catch rates in the sport fishery for summer flounder on Long Island's south shore. The reports prompted investigations between 1956 and 1960, (1) to determine the age and growth, migration, rate of exploitation, population size and feeding habits of the summer flounder in Great South Bay (Poole, 1961, 1962, 1964), and (2) to relate these observations to catch information obtained from the recreational fishery in the same vicinity (Briggs, 1962). The results of these studies (Schaefer, 1966) revealed that:

1. Summer flounder became available to, and were landed by, the recreational fishery at approximately 25.5 centimeters (10 inches) in total length and 1½ years of age.
2. The recreational fishery in Great South Bay depended upon 1- and 2-year-old fish which comprised more than 75 per cent of the catch.
3. Summer flounder in age groups I and II grew at a rate that added an appreciable increment to their length each year, especially during the summer months.
4. Summer flounder inhabiting Great South Bay in late spring and early summer tended to remain resident throughout the entire summer, with little movement to other bays or to the open sea before September. Similarly, there was little indication of in-season recruitment of fish from the ocean into the Great South Bay population after June.
5. A large percentage of summer flounder inhabiting Great South Bay in any one year tended to return to the bay in subsequent years.
6. In-season rates of exploitation by recreational fishing within Great South Bay ranged from 7 per cent to as high as 25 per cent.
7. Monthly catch rates for summer flounder declined sharply from a high in June to a low in August and September during all but one of the four study years.
8. The in-season decline of monthly catch rates could not be directly attributed to changes in the feeding habits of the summer flounder.
9. Recreational catches ranged between 800,000 and 1.8 million summer flounder per year in Great South Bay, while annual estimates of population size ranged from 3.9 to 5.5 million fish.

Based on these findings, a minimum size limit of 35.6 centimeters (14 inches), conforming to that already in effect in the commercial fishery, was recommended, enacted and instituted for the recreational fishery in New York waters as of January 1, 1965. The size limit was designed to allow the young fish to grow rapidly before they were harvested, especially early in the season so that there would be continuous recruitment of fish to legal size during the rest of the fishing season. Thus, the catch and catch rate would be distributed more evenly.

Research on the sport fishery, similar to some of that performed previously, was resumed in Great South Bay on June 1, 1965 to evaluate the effectiveness of the size limit. The research included Petersen tag-recapture experiments and a measure of catch and effort. In 1966, the data showed that the annual catch of summer flounder in Great South

Bay declined to less than 300,000 fish; the estimated population declined to 1.43 million in 1965 and 1.03 million in 1966. The monthly catch rates in 1965 were stable during the fishing season; they declined from 2.04 fish per trip in June to 1.75 fish per trip in August. The monthly catch rate for summer flounder larger than 35.6 centimeters in 1965 increased from 1.21 fish per trip in June to 1.47 fish per trip in August. In June, approximately 43 per cent of the summer flounder population in the bay consisted of fish less than 35.6 centimeters. The catch rate in 1966 declined from 2.57 fish per trip in June to 0.85 fish per trip in August. In June, only 23 per cent of the summer flounder population in the bay consisted of fish less than 35.6 centimeters.

Schaefer (1966) noted that the data gathered in 1965 suggest that, when a large percentage of sub-legal fish are present in the population at the beginning of the fishing period, the catch rate can be stabilized throughout the entire fishing period. In contrast, when the percentage of sub-legal fish in the population is low at the beginning of the fishing period (as it was in 1966), the size regulation apparently has very little effect in supporting the catch rate during July and August.

One striking difference between years of "good" and "poor" fishing lies in the size composition data (Schaefer, unpublished manuscript). During "good" fishing years, the population consists of many small fish. In 1960, fish less than 35.6 centimeters long constituted approximately 70 per cent of the population in Great South Bay. In "poor" fishing years, however, there are fewer small fish. In 1968, for example, fish less than 35.6 centimeters long constituted fewer than 4 per cent of the population. Fishing for summer flounder that year was the poorest ever recorded. It seems reasonable to conclude from these observations, said Schaefer, that variations in fishing success are directly dependent on variations in recruitment of young age groups into the population.

The increase in commercial landings of summer flounder beginning in 1969 and continuing to the present suggest an increase in abundance of the species. In addition, in 1972 and 1973, anglers reported many "short" (less than 35.6 centimeters) summer flounder that were caught and discarded. The presence of these undersize fish indicates good fishing at least for the next two or three years.

Black Sea Bass

The black sea bass never has been an important part of the New York commercial fishery. Over the past 19 years, the peak landings (573 tons) were recorded in 1954. Since then, the landings have declined, and the lowest recorded to date (20 tons) occurred in 1972. The bulk of the catch is divided equally between otter trawls and pots (similar to lobster traps) and is made mostly in near-shore waters.

As with other species, the sport catch of the black sea bass is several times greater than the commercial catch. In 1970, the angler catch in the North Atlantic Region was 279 tons (Deuel, 1973), whereas the comparable commercial catch was 37 tons. In recent years, anglers have complained about their poor catches of black sea bass and its generally low abundance.

This Department has completed a study (Briggs, in manuscript) of the populations of the black sea bass on artificial fishing reefs constructed in the Atlantic Ocean off Fire Island (N.Y.). The observations indicate that the offshore reefs successfully attract and hold populations of black sea bass of a range of ages. Angling success for the species has been most successful over the reefs.

TRENDS AND THE FUTURE OF THE FISHERIES

The review of the trends in the catch and landings of scup, summer flounder and black sea bass shows considerable variation in the production of the fisheries. It is tempting, and would be convenient, to try to assign some cause for the variations, particularly for the generalized declines in landings. Unfortunately, an evaluation of the data in relation to other events makes it clear that there is no single, simplistic factor to which we can point for explanation.

The expanded effort of the large, efficient foreign fishing fleets operating in the Middle Atlantic Bight is commonly blamed for the decline in fish abundance. However, as McHugh (1972) clearly showed, the commercial landings of New York's fisheries for many species including the three discussed here, began to decline before the first foreign vessel appeared in the New York Bight in 1963. The scup has varied widely in abundance since earliest times (Finkelstein, 1969a) and began its most recent decline in 1962. Summer flounder landings were fairly steady from about 1938 (when flounder species were first separately listed in the fisheries statistics) to 1957 when they began to decline. Similarly, the New York landings of black sea bass began to decline rapidly in 1952.

The decline in abundance of the three species may be the result of spawning failures or the poor survival of year classes. There has been a change in the average water temperatures of the Northwest Atlantic (Colton, 1968) which may have created an environment unfavorable to the survival and growth of the eggs and larvae of the three species. Unfortunately, we do not have the data with which to test this hypothesis.

An examination of the commercial fishing effort in New York waters (Jensen, in manuscript) shows a decline in numbers of fishermen and units of gear, thus a reduction in effort. At the same time, total commercial landings of finfish for food also have declined slightly. The recrea-

tional effort, expressed in terms of numbers of anglers, has increased over the past decade. And although the recreational catch has shown the same relative ups and downs as the commercial catch, the total volume landed by anglers is a clear indication of the major exploitation by this group.

The haddock (*Melanogrammus aeglefinus*) fishery in New England is a near-classic demonstration of the results of a combination of massive, increased fishing effort and naturally-caused year-class failures (Graham, 1970). The haddock now is in dangerously low abundance, and some biologists fear it may be nearing economic extinction. There is no suspicion, however, that the same sort of situation may arise with the scup, summer flounder or black sea bass. In fact, the fishing agreements reached in June 1973 between the United States and the USSR and between the United States and Poland will serve to protect these three species (among others) from the fleets of the two nations operating in the Middle Atlantic Bight. The agreements enjoin the foreign vessels from increasing their incidental catches above the levels caught in 1967 and from launching specialized fisheries for the species. (The fleets now primarily seek Atlantic herring, *Clupea harengus,* and Atlantic mackeral, *Scomber scombrus.*) Unfortunately, the agreements do not apply to the nearly 10 other nations that also fish in the Middle Atlantic Bight. Their effort, however, is only a small fraction of that expended by the USSR and Poland.

The available evidence suggests that, for various socio-economic reasons, New York's commercial fishery probably will continue a slow decline in units, effort and landings until it reaches a stable level. The industry then will function efficiently to supply high-quality fresh fish to the restaurant and specialty fish store trade. The three species reviewed here, together with other near-shore fishes, will be important components of the landings.

In contrast, the recreational fishery will continue to become more important with increased numbers of anglers (hence, effort) and increased total landings. Because of this, it is clear that any efforts to manage the populations of finfish of interest to New York's fishermen—as management becomes necessary—must involve the recreational fishery.

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REPRODUCTIVE RATES OF WHITE-TAILED DEER IN NEW YORK STATE[1]

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ABSTRACT

A statewide field collection of female deer which died from various causes during the years 1961–1968 provided a usable sample of 1,644 reproductive tracts. Reproductive rates were calculated for three age groups: fawns, yearlings and 2½-year-old and older deer according to deer range section and bone marrow fat condition. The greatest differences between range sections were found among fawns and yearlings. There also were significant differences in reproductive rate between deer in good physical condition and those in poor physical condition, as determined by bone marrow fat. Corpora lutea counts were recorded for the three age groups by range section, and differences between sections were found to be similar to those for reproductive rates. Embryo-corpora lutea ratios, expressed as percentage of embryos per corpora lutea, consistently approximated 90 to 93 per cent. Range condition was reflected in the variation in reproductive rates between range sections and between age groups within sections. The younger the animal, the more sensitive the reproductive physiological response to environmental differences. This response is immediate as illustrated by annual comparisons of reproductive rates at the Seneca Army Depot. Limitations and biases of this and related reproductive studies are discussed.

A knowledge of the reproductive rates of deer is a valuable tool for the wildlife manager, not only for calculating populations but because they are an accurate index to range quality. Data for the white-tailed deer (*Odocoileus virginianus*), collected in New York between 1936 and 1954, were reported on by Cheatum and Severinghaus (1950) and Severinghaus (1954). Since that time, changes have occurred in both the quality and quantity of deer range in the State, as well as in herd size, age composition, the number of females removed by hunting and other factors. Any or all of these influences may bring about changes

[1]A contribution of Federal Aid in Fish and Wildlife Restoration Project W-89-R. The authors wish to acknowledge the cooperation of the many people who assisted in this study. Field personnel of the Bureau of Law Enforcement and Bureau of Wildlife in the Division of Fish and Wildlife were responsible for collecting deer. The State Police, State Department of Transportation, State Thruway Authority, many county sheriff's departments and town and county road crews were extremely cooperative in reporting and holding road-killed deer. Special thanks are due Frank Church, Gideon Hanggi, Herbert Gaylord, Gary Parsons and Kenneth Dean who removed, stored and transported the specimens to the laboratory at Delmar. John E. Tanck assigned ages to virtually all of the deer collected. Dr. N. S. Urquhart of New Mexico State University was consulted regarding statistical applications and thanks are due him for the statistical procedures used.

in reproductive rates. Therefore, additional data of this sort were collected from 1961 to 1968.

MATERIALS AND METHODS

Female fawns and female adult deer (mostly road-killed animals, plus some killed by dogs and some shot illegally) were collected throughout the State during the late winter and spring each year. For each, the reproductive tract, femur and mandible were preserved and transported to the Wildlife Research Laboratory at Delmar (N.Y.) for examination. The methods of collection were described by Jackson and Hesselton (1973). A usable sample of 1,644 specimens was obtained.

At the Laboratory, the source of each specimen was recorded according to the deer range sections of the State defined by McCaffrey (1966) and shown in Figure 1. The age of each was determined from the mandibular teeth according to Severinghaus (1949), and the fat content of the femur marrow was estimated as described by Cheatum (1949b). The uteri were dissected, and any embryos present were recorded. All ovaries were removed and stored in 10 per cent formalin for a minimum of 12 hours.

Upon removal from the formalin, the ovaries were sectioned and examined for corpora lutea. All corpora lutea, any large developing Graafian

Figure 1. Deer range sections of New York according to McCaffrey (1966).

follicles and large luteinized follicles were measured by making two diameter measurements at right angles to each other. The presence and size of these bodies were recorded for each ovary. In addition, the ovaries of yearlings were examined for corpora albicantia.

The data were first recorded on 3″ x 5″ cards and then transferred to coding sheets (Figure 2) from which they were punched on IBM cards. These cards were then used in conjunction with a Fortran program to obtain the correlations used for analysis.

CALCULATION OF REPRODUCTIVE RATES

Reproductive rate was considered to be the value obtained by multiplying the number of embryos per pregnant female by the percentage of females pregnant. This approach was used because complete data were not available for all specimens. In some instances, the uterus had been ruptured when the animal was killed (e.g., collision with auto) and the embryos were not recovered. Such specimens could be used for determining the percentage of females pregnant, but only specimens with an intact uterus could be used for determining the number of embryos per pregnant female. Further, female fawns breed later than older deer. Therefore, fawns collected prior to February 1 were not used to determine the percentage of females pregnant. However, all pregnant fawns, with an intact uterus, were used to determine the number of embryos per pregnant female. The initial date for judging whether or not yearling and older deer were pregnant was January 1.

RESULTS

The data were analyzed in terms of the actual reproductive rate (i.e., pregnancy and embryo production) and in terms of the frequency of corpora lutea.

Reproductive Rates

Reproductive rates were calculated by age group for each deer range section. They were also compared on a statewide basis for all pregnant females according to their physical condition.

By Age Group and Deer Range Section Reproductive rates and associated data for each deer range section are given in Table 1 for fawns, yearlings and older deer. The rates for range sections with good representative samples are shown graphically in Figure 3 together with the statewide mean.

Three distinct groupings are evident in Figure 3. Deer from Sections 1, 7 and 8 (central Adirondacks, Hudson Highlands and central Catskills, respectively) exhibited the poorest reproductive rates. Deer from Sections 1 and 8 were expected to have poor rates. However, the poor

DEER REPRODUCTION CODING SHEET

License Type	Date Collected Month		Day		Sex	Age		Age Class	County Code		Town Code		Section	Pregnant	Year Collected		Bone Marrow	UTERUS Sexed				Unsexed		Ovaries			Fetal Age in Days			Breeding Date Year		Month		Day		Parturition Date Year		Month		Day		C. A.	
1	16	17	18	19	22	25	26	27	28	29	30	31	32	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
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Figure 2. Coding sheet to which data were transferred preparatory to being punched on IBM cards.

TABLE 1. REPRODUCTIVE RATES OF DEER IN NEW YORK FOR THREE AGE GROUPS ACCORDING TO RANGE SECTION, 1961–1968

Deer range section	Occurence of pregnancy			Occurrence of embryos			Reproductive rate*
	Females examined	Females pregnant		Females with embryos	Number of embryos		
		Number	Per cent		Total	Per female	
Fawns							
1	70	3	4.3	3	5	1.67	0.07
2	16	8	50.0	7	11	1.57	0.78
3	16	2	12.5	2	3	1.50	0.19
4	33	7	21.2	6	6	1.00	0.21
5	74	14	18.9	14	16	1.14	0.22
6	15	3	20.0	2	3	1.50	0.30
7	20	0	0.0	0	0	0.00	0.00
8	55	3	5.5	2	2	1.00	0.05
9	246	47	19.1	56	74	1.32	0.25
10	95	50	52.6	38	44	1.16	0.61
Total	640	137	21.4	130	164	1.26	0.27
Yearlings							
1	43	37	86.0	32	39	1.22	1.05
2	11	11	100.0	9	18	2.00	2.00
3	3	2	66.7	2	3	1.50	1.00
4	11	11	100.0	9	18	2.00	2.00
5	35	31	88.6	27	42	1.55	1.37
6	6	6	100.0	6	12	2.00	2.00
7	9	8	88.9	7	7	1.00	0.89
8	41	33	80.5	28	36	1.29	1.04
9	155	145	93.5	130	207	1.59	1.49
10	50	49	98.0	44	82	1.86	1.82
Total	364	333	91.5	294	464	1.58	1.45
2½-year-old and older deer							
1	118	104	88.1	93	153	1.65	1.45
2	8	8	100.0	7	12	1.71	1.71
3	10	10	100.0	9	16	1.78	1.78
4	18	18	100.0	16	30	1.87	1.87
5	62	59	95.2	51	103	2.02	1.92
6	22	19	86.4	15	27	1.80	1.56
7	32	30	93.8	24	41	1.71	1.60
8	81	69	85.2	59	98	1.66	1.41
9	236	228	96.9	195	378	1.94	1.87
10	53	48	90.6	43	83	1.93	1.75
Total	640	593	92.7	512	941	1.84	1.71

* Represents percentage of females pregnant multiplied by number of embryos per female and divided by 100.

rates in Section 7 were unexpected. Sections 5 and 9 (Hudson Valley and Southern Tier, respectively) had rates close to the statewide mean for fawns and yearlings, and somewhat above the mean for older animals. Sections 2 and 10 (St. Lawrence Valley and Lake Plains, respectively), which are areas of low deer numbers and abundant year-around food supplies, had rates considerably higher than the statewide mean for the fawn and yearling age groups; however, the rate for adults from both of these sections was below that for Sections 5 and 9.

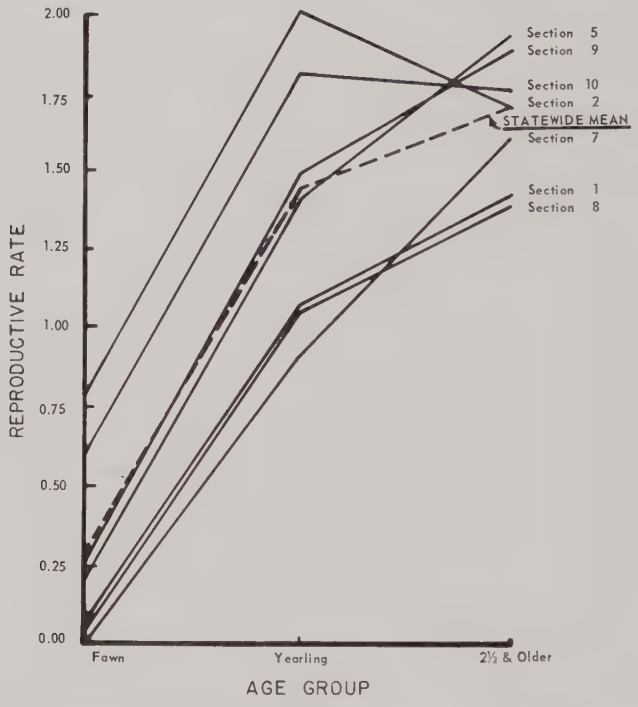

Figure 3. Reproductive rates of deer according to age group for range sections with good representative samples.

The data indicate that the change in reproductive rate between adjoining deer range sections is usually gradual. For example, the rates as shown in Table 1 for Sections 9 and 10 were, respectively, 0.25 and 0.61 for fawns, 1.49 and 1.82 for yearlings, and 1.87 and 1.75 for deer 2½ years old or older. The values for the fawns and yearlings were significantly different when tested by chi-square. However, when the rates for a series of towns astride the boundary between these two sections were compared, they were found to be similar. In Section 10, reproductive rates were highest in the towns bordering Lake Ontario and lower along the boundary with Section 9. Also, there may be areas within a range section that exhibit rates markedly different from the average for the section.

Statistical Comparison of Reproductive Rates In order to compare reproductive rates, a modified *t*-test (as recommended by Dr. N. S. Urquhart) was employed which incorporated a standard *g*-value from normal tables. The *g*-value in this case is 2.39 at a .05 confidence level. The comparison is made by taking the square root of the sum of standard variances for the two reproductive rates being compared, and multiplying it by 2.39. If the result is greater than the difference between

the two reproductive rates, the rates do not differ significantly. When the result is less than the difference betwen the two rates, they may be considered significantly different.

For the purpose of this test, reproductive rates were calculated for each age group by the equation

$$r_i = \frac{y_{i1} + 2y_{i2}}{m_i}$$

where r_i = the reproductive rate
y_{i1} = total number of females with one embryo
y_{i2} = total number of females with two embryos
m_i = total number of females
2 = constant

The variance for each reproductive rate was calculated as follows

$$s_i^2 = \frac{1}{m_i}\left[\frac{y_{i1}}{m_i} + 4\frac{y_{i2}}{m_i} - (r_i)^2\right]$$

where
s_i^2 = the variance
4 = constant

Certain limitations with respect to this procedure should be pointed out. To make comparisons, it was necessary to calculate the standard variance for each reproductive rate. The variance was derived by considering three categories of females, i.e., those with no embryos, those with one embryo and those with two embryos (see Table 2). Specimens with triplets were not included because their rare occurrence would not provide minimum samples of four necessary for meaningful interpretation of results. Even with the data used, comparisons between some range sections could not be made due to a lack of samples of at least four in all three categories considered. Nevertheless, the rates in Table 2 are reasonable approximations of the calculated reproductive rates in Table 1; however, the significance of the tests in Table 2 should not be applied to the corresponding reproductive rates in Table 1. The purpose in making these tests was to show that significant differences in reproductive rates between deer range sections do exist. If, in future collections, sufficient embryo data should be available, other pregnancy data could be omitted in calculating reproductive rates. Direct statistical comparisons could then be made using the technique described here.

The data for these *t*-test comparisons of the reproductive rates by age group and deer range section are given in Table 2. The *t*-values, and the results of the comparisons that could be made, are given in Table 3. In spite of the fact the statistical test employed did not allow comparisons for all range sections, there were some obvious differences. For example,

Table 2. Statistical Comparison of Reproductive Rates of Deer For Three Age Groups According to Range Section

Deer range section	Specimens suitable for comparison According to number of embryos 0	1	2	Total*	Reproductive rate (r_i)	Variance (s_i^2)
Fawns						
1	67	1	2	70	§	§
2	9	3	4	16	§	§
3	14	1	1	16	§	§
4	27	6	0	33	§	§
5	60	12	2	74	§	§
6	13	1	1	15	§	§
7	20	0	0	20	§	§
8	53	2	0	55	§	§
9	190	38	18	246	0.301	0.0014
10	57	32	6	95	0.463	0.0039
Total	510	96	34	640	xxx	xxx
Yearlings						
1	6	25	7	38	1.026	0.0090
2	0	1	7	8	§	§
3	1	1	1	3	§	§
4	0	1	7	8	§	§
5	4	12	15	31	1.355	0.0157
6	0	0	6	6	§	§
7	1	7	0	8	§	§
8	8	21	6	35	0.943	0.0113
9	10	53	77	140	1.479	0.0028
10	1	10	30	41	1.707	0.0094
Total	31	131	156	318	xxx	xxx
2½-year-old and older deer						
1	14	36	54	104	1.385	0.0048
2	0	2	5	7	§	§
3	0	2	7	9	§	§
4	0	4	10	14	1.714	0.0146
5	3	3	44	50	§	§
6	3	4	10	17	1.412	0.0350
7	2	7	17	26	1.577	0.0153
8	12	20	39	71	1.380	0.0081
9	8	37	133	178	1.702	0.0017
10	5	7	32	44	1.614	0.0105
Total	47	122	351	520	xxx	xxx

* Totals for yearlings and older deer are less than the total numbers examined as given in Table 1 because females with triplets were excluded as constituting too small a sample and because some females which could be included in Table 1 as being pregnant had to be omitted here since the corresponding number of embryos was not known.

§ Insufficient sample.

referring to Tables 1 and 2, the differences between Sections 1, 3, 4, 5, 7 and 8 and Sections 2 and 10 are obvious for the fawn age group. The differences for: Section 1 versus Sections 2 and 4; Section 7 versus Sections 2, 4, 6, 9 and 10; and Section 8 versus Sections 2, 4 and 6 were

TABLE 3. SIGNIFICANCE OF COMPARISONS BETWEEN RANGE SECTIONS FOR REPRODUCTIVE RATES OF DEER AS DERIVED IN TABLE 2

Deer range sections compared	Difference in rates (r_1)	*t*-value	Significance§
Fawns			
9 vs. 10	0.162	0.175	n.s.
Yearlings			
1 vs. 5	0.329	0.376	n.s.
1 vs. 8	0.083	0.340	n.s.
1 vs. 9	0.453	0.260	*
1 vs. 10	0.681	0.354	**
5 vs. 8	0.412	0.392	*
5 vs. 9	0.124	0.325	n.s.
5 vs. 10	0.352	0.354	n.s.†
8 vs. 9	0.536	0.284	*
8 vs. 10	0.764	0.317	**
9 vs. 10	0.228	0.227	*†
2½-year-old and older deer			
1 vs. 4	0.329	0.334	n.s.
1 vs. 6	0.027	0.477	n.s.
1 vs. 7	0.192	0.339	n.s.
1 vs. 8	0.005	0.272	n.s.
1 vs. 9	0.317	0.193	*
1 vs. 10	0.229	0.296	n.s.
4 vs. 6	0.302	0.532	n.s.
4 vs. 7	0.137	0.414	n.s.
4 vs. 8	0.334	0.360	n.s.
4 vs. 9	0.012	0.305	n.s.
4 vs. 10	0.100	0.379	n.s.
6 vs. 7	0.165	0.536	n.s.
6 vs. 8	0.032	0.496	n.s.
6 vs. 9	0.290	0.458	n.s.
6 vs. 10	0.202	0.510	n.s.
7 vs. 8	0.197	0.365	n.s.
7 vs. 9	0.125	0.311	n.s.
7 vs. 10	0.037	0.384	n.s.
8 vs. 9	0.322	0.236	*
8 vs. 10	0.234	0.326	n.s.
9 vs. 10	0.088	0.264	n.s.

§ Indicated as: n.s.=not significant; *=significant at .05 confidence level; **=significant at .01 confidence level.
† Borderline value.

probably real for the yearlings. Further, the difference between Sections 1 and 8 and Section 5 were probably real for the adults.

EFFECT OF PHYSICAL CONDITION Because it was felt that reproductive capacity varied between deer in good physical condition and deer in poor physical condition, separate tabulations were made comparing reproductive rates according to the percentage of marrow fat present in the femur bone. All deer with a 20 per cent or more fat content were considered to have "good" bone marrow. Those with less than a 20 per cent fat content were classed as having "poor" bone marrow. Specimens lacking the femur were recorded as "undetermined". The comparative

Table 4. Comparative Reproductive Rates of Deer For Three Age Groups According to Bone Marrow Fat Condition

Age group	Bone marrow fat condition						Total	
	Good		Poor		Undetermined			
	Number examined	Reproductive rate	Number examined	Reproductive rate	Number examined	Reproductive rate	Number examined	Reproductive rate
Fawn	398	0.25	149	0.12	93	0.59	640	0.27
1½	274	1.51	40	1.25	50	1.24	364	1.45
2½+	454	1.76	89	1.48	97	1.69	640	1.71
Total	1,126	xxx	278	xxx	240	xxx	1,644	xxx

reproductive rates, derived in the same manner as in Table 1, are given in Table 4.

Based on the data in Table 4, *t*-test comparisons of the reproductive rates for the various age classes according to their bone marrow condition revealed the following.

1. Good bone marrow
   a. A highly significant difference between fawns and yearlings, and betweens fawns and 2½-year-old and older deer.
   b. A borderline (barely significant) difference between yearlings and older deer.
2. Poor bone marrow
   a. A highly significant difference between fawns and yearlings, and between fawns and 2½-year-old and older deer.
   b. No significant difference between yearlings and older deer.
3. All deer (including undetermined bone marrow)
   a. A significant difference between fawns and yearlings, and between fawns and 2½-year-old and older deer.
   b. A significant difference between yearlings and 2½-year-old and older deer.

In all cases, the reproductive rates for fawns were significantly different from those for yearlings and from those for 2½-year-old and older deer at the .05 confidence level. The rates for yearlings did not differ significantly from those for 2½-year-old and older deer in the poor bone marrow category. However, when all data were combined, there was a significant difference between the rates for yearlings and those for 2½-year-old and older deer.

One of the fallicies inherent to this particular statistical test is that female deer with triplets, and females known to have been pregnant but for which there was no accurate embryo count, are excluded. Inclusion of these data would have resulted in even greater differences in reproductive rates between the age groups tested.

When the reproductive rates for deer having good bone marrow and those having poor bone marrow were compared within the same age group, the *t*-test showed that differences among fawns and among 2½-year-old and older deer were significant at the .05 confidence level. The difference was not significant for yearlings.

Frequency of Corpora Lutea

A corpus luteum is the opaque whitish body that develops in an ovary at the point where a Graafian follicle ruptured at the time of ovulation. Counts of corpora lutea are an index of fertility and a useful supplement to embryo data.

By Age Group and Deer Range Section The occurrence of corpora lutea for each deer range section is given in Table 5 by age group of the deer examined. The differences in counts, between sections, followed closely the pattern for reproductive rates. Deer from poor range or from range where deer numbers exceeded the ability of that range to support them (notably Sections 1, 3, 7 and 8) exhibited low corpora lutea counts. Also, as with reproductive rates, deer from range where the carrying capacity was not exceeded exhibited high corpora lutea counts.

These data indicate that differences in basic reproductive potential, between deer in various conditions of physical vigor, are not just the result of *in utero* embryo death and resorption. Female deer in poor physical condition simply do not have as many ova developing in, or rupturing from, the ovaries as do females in better physical condition. On poor range, many females do not ovulate at all in some years. The senior author has examined reproductive tracts from certain localities in the central Adirondacks and Vermont, as well as from Anticosti Island in Canada, where the range was very poor. They showed that, in these areas, fawns almost never ovulated and that as many as half the yearlings and frequently as many as 25 to 35 per cent of the 2½-year-old and older females failed to ovulate in a given year. He also has examined ovaries from 4½-year-old females that had never ovulated. It is recognized that factors other than poor nutrition may in some situations be responsible for low fertility. However, poor reproductive potential almost always occurs in areas that are known to be poor deer habitat. Other physical indices, such as small average antler size, low dressed weight and actual starvation, are usually associated with ranges where female deer have low reproductive rates.

Embryo-Corpora Lutea Ratios Embryo-corpora lutea ratios were obtained only for specimens that had complete and intact reproductive tracts. The data are presented in Table 6 in which the relationships are given both as ratios and as percentages.

Table 5. Frequency of Corpora Lutea For Three Age Groups of Deer According to Range Section

Deer range section	Females examined	Females with corpora lutea		Number of corpora lutea		Frequency of corpora lutea*
		Number	Per cent	Total	Per female with corpora lutea	
Fawns						
1	85	2	2.4	3	1.50	0.04
2	15	5	33.3	8	1.60	0.53
3	18	1	5.6	2	2.00	0.11
4	33	6	18.2	6	1.00	0.18
5	65	21	33.8	29	1.38	0.47
6	14	1	7.1	2	2.00	0.14
7	22	0	0.0	0	0.00	0.00
8	61	5	8.2	5	1.00	0.08
9	232	42	18.1	61	1.45	0.26
10	89	40	44.9	51	1.28	0.57
Total	634	123	19.4	167	1.36	0.26
Yearlings						
1	45	37	82.2	50	1.35	1.11
2	8	8	100.0	19	2.37	2.37
3	3	2	66.7	3	1.50	1.00
4	9	9	100.0	19	2.11	2.11
5	30	26	86.7	45	1.73	1.50
6	6	6	100.0	12	2.00	2.00
7	8	7	87.5	8	1.14	1.00
8	35	28	80.0	37	1.32	1.06
9	127	119	93.7	207	1.74	1.63
10	38	38	100.0	77	2.03	2.03
Total	309	280	90.6	477	1.70	1.54
2½-year-old and older deer						
1	88	74	84.1	125	1.69	1.42
2	5	5	100.0	10	2.00	2.00
3	5	5	100.0	8	1.60	1.60
4	12	12	100.0	24	2.00	2.00
5	47	44	93.6	95	2.16	2.02
6	23	19	82.6	35	1.84	1.52
7	30	27	90.0	47	1.74	1.57
8	53	45	84.9	78	1.73	1.47
9	198	195	98.5	421	2.16	2.13
10	43	39	90.7	77	1.97	1.79
Total	504	465	92.3	920	1.98	1.83

* Represents percentage of females with corpora lutea multiplied by number of corpora lutea per female and divided by 100.

A *t*-test was used to compare the percentages for females having good bone marrow with those having poor bone marrow. There was a significant difference (at the .05 confidence level) in both the fawn and yearling age groups. No significant difference occurred in the 2½-year-old and older group. When yearlings and older females were combined, the differences became non-significant. These data demonstrate the need for separating such data according to the three age groups.

TABLE 6. EMBRYO-CORPORA LUTEA RATIOS FOR DEER WITH DIFFERENT LEVELS OF BONE MARROW FAT ACCORDING TO AGE

Age (years)	Number females examined	Number embryos	Number corpora lutea	Embryo-corpora lutea ratio	Implanted embryos as percentage of corpora lutea		
					Single age group	1 year & older	2 years & older
Good bone marrow							
½	81	102	106	1 : 1.04	96	xxx	xxx
1½	205	330	353	1 : 1.07	93		xxx
2½	100	186	199	1 : 1.07	93		
3½	76	144	159	1 : 1.10	90		
4½	40	76	80	1 : 1.05	95		
5½	35	64	71	1 : 1.11	90	93	
6½	32	56	63	1 : 1.12	88		92
7½	22	40	44	1 : 1.10	90		
8½–9½	13	23	24	1 : 1.04	95		
10½+	5	9	10	1 : 1.11	90		
Total	609	1,030	1,109	1 : 1.08	93	xxx	xxx
Poor bone marrow							
½	13	15	17	1 : 1.13	88	xxx	xxx
1½	30	45	51	1 : 1.13	88		xxx
2½	12	22	22	1 : 1.00	100		
3½	5	10	12	1 : 1.20	83		
4½	16	28	30	1 : 1.07	93		
5½	9	17	17	1 : 1.00	100	90	
6½	2	6	6	1 : 1.00	100		93
7½	6	8	10	1 : 1.25	80		
8½–9½	6	11	11	1 : 1.00	100		
10½+	5	8	10	1 : 1.25	80		
Total	104	170	186	1 : 1.09	91	xxx	xxx
Undetermined bone marrow							
½	25	41	44	1 : 1.07	93	xxx	xxx
1½	38	59	65	1 : 1.10	91		xxx
2½	17	35	40	1 : 1.14	88		
3½	8	14	18	1 : 1.29	77		
4½	9	18	18	1 : 1.00	100		
5½	2	4	4	1 : 1.00	100	91	
6½	3	6	6	1 : 1.00	100		91
7½	7	11	12	1 : 1.09	92		
8½–9½	8	15	16	1 : 1.07	94		
10½+	2	4	4	1 : 1.00	100		
Total	119	207	227	1 : 1.10	92	xxx	xxx

COMPARISON OF REPRODUCTIVE RATES FOR 1936–1954 AND 1961–1968

Cheatum and Severinghaus (1950) discussed fertility rates for deer in New York in relation to range conditions and described five regions, i.e., central Adirondacks, Adirondack periphery, central Catskills, Catskill periphery and western. Severinghaus (1954) summarized data collected between 1936 and 1954 according to these regions. Present data, for 1961–1968, for the deer range sections currently recognized (Figure

1) were combined to represent approximately the regions formerly used so that the rates for the two periods could be compared (Table 7). Cheatum and Severinghaus did not separate yearlings from older deer, so these groups were likewise combined.

The rates for yearlings and older deer in the central Adirondacks and for deer of all ages in the Adirondack periphery were slightly greater for the 1961–1968 period than for the earlier period, probably as a result of a series of mild winters that occurred during the later years. However,

Table 7. Comparative Reproductive Rates For Deer in Five Regions of New York According to Data Collected in 1936–1954 and in 1961–1968

	Fawns				Yearlings and older deer			
	Number examined		Reproductive rate		Number examined		Reproductive rate	
Region*	1936–1954	1961–1968	1936–1954	1961–1968	1936–1954	1961–1968	1936–1954	1961–1968
Central Adirondacks	10	70	0.10	0.07	92	161	1.13	1.35
Adirondack periphery	17	65	0.24	0.35	25	61	1.59	1.84
Central Catskills	22	55	0.17	0.05	48	122	1.41	1.29
Catskill periphery	66	109	0.25	0.19	120	166	1.63	1.71
Western	88	341	0.47	0.35	142	494	1.78	1.73

* Designations of regions are from Cheatum and Severinghaus (1950). Data for 1936–1954 period are from Severinghaus (1954) and were recorded according to these regions. Data from present study, recorded according to deer range sections defined by McCaffrey (1966), are grouped to correspond in scope as closely as possible to those regions as follows: Section 1=central Adirondacks; Sections 2, 3 and 4=Adirondack periphery; Section 8=central Catskills; Sections 5, 6 and 7=Catskill periphery; Sections 9 and 10=western.

the rates for the central Adirondacks remained lower than those elsewhere except for the central Catskills. The most notable change since 1954 was in the central Catskills where the rates for deer of all ages decreased to the lowest levels in the State. Rates in the Catskill periphery were slightly lower for fawns and slightly higher for older deer during the later period than they were during the earlier years. Reproductive rates for deer in western New York remained essentially the same. No statistical tests could be run since the regional boundaries for the two periods did not exactly correspond.

DISCUSSION

To a large degree, current studies of reproduction in wild ungulates, particularly deer, are based on and refer to the work of Cheatum (1949a). Cheatum described a technique for macroscopic ovarian analysis which allows determination of two years of reproductive information, i.e., an estimate of current reproduction based on corpora lutea counts and a estimate of the previous year's reproduction based on pigmented scars of old corpora lutea (*corpora albicantia*). Two assump-

tions are necessary to evaluate such data: (1) that corpora albicantia are observable for at least several months after parturition, and (2) that corpora albicantia are distinguishable from corpora lutea by their smaller size and pigmentation.

Using this technique, Morton and Cheatum (1946) and Cheatum and Severinghaus (1950) found variations in the fertility of deer in different parts of New York that reflected differences in range conditions and related population densities. This relationship was most dramatic in connection with winter concentration areas where available food supplies were limited. There is also evidence that poor summer range may affect deer productivity (Julander et al., 1961).

The present data substantiate a direct relationship between range conditions and reproductive rates in white-tailed deer. Reproductive rates and actual reproduction were high in areas (e.g., Section 10) where the deer population, even though heavily harvested, was in balance with the available food supply. Conversely, in areas (e.g., Sections 1 and 8) where deer numbers exceeded the available food supply, they were much lower.

Louis Verme has done considerable research on the effects of varied nutritional levels on white-tailed deer. Studies of penned deer on various dietary levels (Verme, 1962) showed a direct relationship between nutritional level and fawn mortality. Adult does on starvation diets produced considerably fewer fawns than does on diets providing higher nutrition. Correspondingly, postnatal losses among fawns from does on starvation diets amounted to 33 per cent, compared with 7 per cent among fawns from does on adequate diets.

In later experiments (Verme, 1965, 1967) he found that seasonal changes in diet markedly affected the reproductive capacity of all female deer. Apparently, spring, summer and fall diets may be as important in determining reproduction the following spring as is the winter diet. Underfed deer, that lost fawns just prior to or just after parturition and were then placed on an adequate diet, gained weight rapidly and had high reproductive rates the following spring. However, poorly nourished females that reared fawns had a much lower reproductive rate the following spring. Food shortages affected the reproductive capacity more severely for yearling does than for adult does.

The data collected in the present study showed that malnourished deer were carrying fewer embryos than well-fed deer and that reproductive rates were different for deer having good bone marrow compared with deer having poor bone marrow. For management purposes, however, all female deer inhabiting a particular area are contributing their reproductive potential to the population and, therefore, must be considered when over-all reproductive rates are calculated. In fact, in many areas of the Northeast, if one were to exclude those deer with poor bone

marrow, there would be no sample. Experience in New York, as well as in Vermont (McLaughlin et al., 1971) and elsewhere, has shown that poorly nourished dams are successfully giving birth to fawns, and rearing them, even though their total reproductive capacity is low. Reproductive rates in Table 1 are composite rates for deer in all categories of bone marrow fat condition.

Data on the frequency of corpora lutea are useful for assessing the reproductive potential of deer because they are easier to obtain than data on embryos which must be collected during the actual period of pregnancy. In most studies using data on corpora lutea, the reproductive tracts are collected from deer taken by hunters during the fall hunting season (November–December). This approach has a serious drawback: many females, when taken, are not pregnant and may not even have ovulated. When only corpora lutea data are available, information on embryo-corpora lutea ratios, such as that given in Table 6, will aid in interpretation. Further, comparison of the data in Tables 1 and 6 indicates that there is a consistent relationship between reproductive rates and corpora lutea counts.

Embryo-corpora lutea ratios are used to determine the magnitude of losses among fertilized ova and *in utero* embryos. Golly (1957), Haugen and Trauger (1962) and Hesselton and Jackson (1971) reported that resorption of embryos is common in areas where female deer are living under conditions of stress. If there are significant differences between corpora lutea counts and *in utero* counts, one might expect resorption and/or abortion to be the reason. However, Hesselton and Jackson found only 35 cases of dead embryos *in utero* while examining 2,069 pregnant deer. As noted in Table 6, the difference between the number of corpora lutea and the number of embryos (reciprocal of implanted embryos as percentage of corpora lutea) varied from 0 to 23 per cent. In most instances, it was on the order of 7 to 10 per cent. In other words, 90 to 93 per cent of the corpora lutea were represented by embryos.

There are several possible explanation for such losses. Large, unruptured, luteinized follicles can be mistakenly identified as corpora lutea. Fertilized ova can fail to implant in the uterine wall. Obstructions or constrictions in the oviduct can prevent the ova from passing through to the uterus. Villi, at the oviduct opening, could fail to "pick up" the ova after it was released from the Graafian follicle. Even if the early embryo became implanted and lived for several days before dying, it would be difficult to detect macroscopically. All of these factors probably contribute to this discrepancy between corpora lutea and embryo counts.

The authors attempted to record the presence of corpora albicantia in the sectioned ovaries of all yearling females. Such data are, at best, questionable when these small structures are observed macroscopically. It is difficult to detect the "true" corpora albicantia from other struc-

tures in the ovary. Unruptured Graafian follicles become luteinized occasionally and resemble a corpus luteum, and, as they degenerate, they can resemble a corpus albicantia. Corpora lutea of estrus can also resemble corpora albicantia as they degenerate. Seasonal variations in the onset of estrus, varying stages of development of ovarian structures and size of the corpus luteum complicate ovarian analysis for corpora albicantia. In virtually all cases, however, large Graafian follicles and large luteinized follicles can be differentiated from corpora lutea without the aid of a microscope.

Preliminary tabulations of the incidence of corpora albicantia in yearling deer were made and compared with embryo and corpora lutea counts for fawns. The incidence of corpora albicantia was so low in comparison with that of corpora lutea the data were not analyzed further. Corpora albicantia either were not present or had become indistinguishable as an ovarian structure. These findings would indicate that the presence or absence of corpora albicantia is not a reliable means of determining reproductive potential in white-tailed deer, unless collections are made within 6 or 7 months post-partum. It is felt that, even then, the presence of a corpus albicantia indicates only that the deer had ovulated; it does not mean that she had been bred or that she had given birth to a fawn.

Few studies of reproductive rates have separated data for yearlings from those of older deer. Difficulty in obtaining adequate samples has probably been the major deterrent. However, data presented in Tables 1 and 6 illustrate the need for considering these age groups separately. The reproductive rates for fawns and yearlings are more sensitive to changes in range condition than are those for older deer (Golly, 1957; Haugen and Trauger, 1962). Recently, during a controlled hunt at the Seneca Army Depot in western New York, administrative problems prevented removal of an adequate number of deer. This resulted in an overpopulation, and 2 years later the reproductive rate for female fawns had dropped from 0.43 to 0.04. Continuation of this overpopulation resulted in the rate among fawns remaining low, but the rate among yearlings was not affected.

Evidence, such as this, indicates that annual collections of reproductive information would be needed for an intensive study of population dynamics. However, for the purposes of practical deer management, large-scale collections of such data would probably be needed no oftener than every five years. Further, it is probably not necessary to collect and analyze reproductive information from all age groups. As indicated in the present study, female fawns are the most sensitive to range conditions. Once basic data are available for all age groups, it is only necessary to collect and analyze data for fawns until it is found that the reproductive rate for this age group has changed significantly.

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USE OF POWDERED ACTIVATED CARBON TO ELIMINATE ROTENONE TOXICITY IN STREAMS[1]

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ABSTRACT

Suspensions of powdered activated carbon were found to adsorb rotenone and eliminate toxicity to rotenone-sensitive fish in real and simulated stream situations. Laboratory tests showed that carbon-rotenone systems do not quickly reach equilibrium, and that appropriate concentrations and contact times can be estimated more accurately from a rate equation than from adsorbtion isotherms. In general, application at 30 ppm is adequate and will detoxify commonly used rotenone concentrations in 12 to 21 minutes. Required contact time is inversely proportional to carbon concentration and does not change greatly with increased rotenone concentration. Polysorbate 80 (Tween 80) and certain liquid dishwashing detergents appear to release adsorbed rotenone into water. Carbon had a half-life in suspension of 22 hours in laboratory jars. It handled well as a 10 per cent slurry, but it did not form even moderately stable 30 ppm suspensions in stream water unless introduced through a rotary mixing chamber. Even here, stability was markedly poorer than in jars. Carbon treatment causes a temporary black-to-gray discoloration of the stream bottom. Rotenone adsorbtion in stream tests corresponded well with predictions based on laboratory experiments. Activated carbon treatment is a viable alternative to potassium permanganate detoxification for use in unpolluted, relatively small streams.

It is well known that activated carbon filtration will remove rotenone from water (Cohen et al., 1960). It seemed possible, therefore, that introduction of a slurry of powdered activated carbon into a stream at the downstream end of a rotenone-treated segment might be effective in rendering downstream waters non-toxic. The agent commonly used for this purpose is potassium permanganate, which might be considered disadvantageous in some situations because of the red color it imparts to stream water, and because of the rather narrow safety margin between effective concentrations and concentrations toxic to game fish (Engstrom-Heg, 1972). Carbon adsorbtion, if it could be made to work in the stream environment, would be an alternative method that could be used in stream reclamation projects where there were scientific, esthetic or public-relations objections to the use of potassium permanganate. This paper reports the results of a series of experiments conducted at the DeBruce Laboratory at Livingston Manor (N.Y.) on rotenone and powdered activated carbon.

The study began with laboratory tests of rotenone adsorbtion. In the course of this work, it was accidentally discovered that the common non-ionic surfactant polysorbate 80 (Tween 80) interfered with rotenone

[1]A contribution of Federal Aid in Fish and Wildlife Restoration Project F-9-R.

adsorbtion. This substance is used as an emulsifier in certain processed foods and is a common ingredient of mild liquid detergents used for dishwashing. Since this and similar substances could be expected to occur in waters receiving domestic drainage, further experiments were conducted to test the effects of low concentrations of polysorbate 80 and various commercial detergents on carbon adsorbtion of rotenone. Field tests were conducted to determine the best method of introducing carbon into streams. Finally, a bolt of rotenone was successfully detoxified with activated carbon in a small stream near the Laboratory.

METHODS

Charcoals used were Nuchar Aqua A and Nuchar C115N.[2] Test fish were yearling brown trout (*Salmo trutta*) of Catskill Hatchery origin. The fish were not fed during the 48-hour period before the experiment. All laboratory tests were conducted in laboratory spring water (pH, 6.8; total dissolved solids, 22 ppm; total alkalinity, 11 ppm) held at 65° F. Test vessels were 5-gallon glass jars containing 10 liters of water to which various concentrations of Noxfish[3] had been added. A lapse of 4 hours was allowed to assure full solution of the rotenone (Loeb and Engstrom-Heg, 1970).

In a typical test, a weighed amount of carbon was prepared as a slurry in a small volume of water, added to a test jar and agitated gently for a measured time with an electric stirrer. At the end of this contact period, the mixture was pumped quickly through a glass-wool filter to remove the carbon. A control jar was treated in the same maner, except for the addition of carbon. The glass wool was discarded after each test. Test fish were then added, and the time to loss of equilibrium was used to estimate the residual rotenone concentration (Loeb and Engstrom-Heg, 1971).

In tests involving detergents and surfactants, filtration was omitted, and the detergent or surfactant was added either with the carbon or at the end of a contact period known to cause detoxification. Control jars received identical treatment, but without the detergent or surfactant. A second control received only the detergent or surfactant.

Stability of carbon suspensions in laboratory and stream tests was estimated by measuring transparency with a Spectronic 20 colorimeter-spectrophotometer set at 500 mμ. The relationship between transparency and carbon concentration was found to be linear within the 5–50 ppm range (Table 1).

Ten per cent stock slurries were prepared by adding 35-pound sacks

[2] Both products of Westvaco Corporation, Chemical Division, Covington, Va.
[3] S. B. Penick & Co., Jersey City, N.J. Noxfish consists of: rotenone 5%; other cube extractives, 10%; solvents and emulsifiers, 85%.

Table 1. Transparency of Nuchar Aqua A Suspensions Measured at 500 mμ

Carbon concentration (ppm)	Light transmittance (per cent)
5	97.5
10	95.0
15	92.5
20	90.0
25	87.5
30	85.0

of activated carbon to 55-gallon drums containing 37.7 gallons of water, allowing the mixture to stand overnight and stirring. In stream tests, the carbon slurry was introduced into the stream at a constant rate with a siphon-drum apparatus, which in later tests was combined with a mixing chamber based on a live box used by German workers for holding marine invertebrates in tidal currents (Jatzke, 1970). (Descriptions of both pieces of apparatus are being prepared for publication.)

On May 23, 1973, a 200-foot section of a small stream near the Laboratory was treated, for 90 minutes, with 0.8 ppm of 5 per cent emulsifiable rotenone. Activated carbon was introduced as a 10 per cent slurry at the downstream end of the section via a siphon drum and mixing chamber at a mean rate of 38 ppm for 150 minutes. Stream discharge was 1.4 cubic feet per second throughout the test, and mean velocity was 0.46 feet per second, based on measurements of salt dilution and travel time (Engstrom-Heg, 1971). Fingerling rainbow trout (*Salmo gairdneri*) were placed in live boxes at points 300, 400 and 500 feet downstream from the carbon introduction point.

RESULTS

The results of the various tests are presented separately.

Laboratory Adsorbtion Tests

Preliminary tests, in which fish were added at the end of the contact period without removal of carbon, so that adsorbtion may have continued after addition of the fish, indicated that 15 ppm of Nuchar Aqua A was sufficient to bring 1 ppm of Noxfish below the toxicity threshold for brown trout (about 0.03 ppm) when the fish were added at the end of 15 minutes contact. When similiar tests were attempted with a freshly-mixed Noxfish dispersion, a residue corresponding in toxicity to 0.14 ppm Noxfish remained, indicating that activated carbon, like potassium permanganate (Engstrom-Heg, 1972), is relatively ineffective against the colloidal rotenone in a freshly-prepared dispersion. Tests using Nuchar C115N indicated that 20 ppm were needed to achieve

Table 2. Adsorbtion of Rotenone by 15 ppm Nuchar Aqua at 65° F.*

Rotenone-carbon contact time (minutes)	Residual Noxfish concentration (ppm)
0 – 1	0.38
10 – 11	0.062
15 – 16	0.047
20 – 21	0.045
25 – 26	0.03 (approx.)§
30 – 31	<0.03†

* Adsorbtion arrested by pumping mixture through a glass-wool filter; initial rotenone concentrations = 1.0 ppm Noxfish; residual concentrations estimated from brown trout bio-assay.
§ Fish showed distress, but survived.
† Fish survived without distress.

Table 3. Adsorbtion of Rotenone by Nuchar Aqua A at 65° F.*

Initial Noxfish concentration (ppm)	Carbon concentration (ppm)	Residual Noxfish concentration at 15 minutes	Required carbon concentrations (from Equation 3)
1.0	26	0.03 (approx.)§	29
2.0	31	0.049	35
2.0	35	<0.03†	35
3.0	34	0.056	39
4.0	36	0.052	41

* Adsorbtion arrested by pumping mixture through a glass-wool filter at end of 15 minutes; residual concentrations estimated by brown trout bio-assay.
§ Fish showed distress, but survived.
† Fish survived without distress.

results similar to those obtained with 15 ppm Nuchar Aqua A. The latter was, therefore, used in all further tests.

When the mixture was filtered at the end of the contact period, detoxification was obtained after 26 to 30 minutes contact, using 15 ppm Nuchar Aqua A against 1 ppm Noxfish (Table 2). When the contact time was held to 15 minutes, and the carbon concentration was varied, detoxification was obtained with 26 ppm carbon at 1 ppm Noxfish and 35 ppm carbon at 2 ppm Noxfish (Table 3).

Effects of Surfactants and Detergents

It was found that polysorbate 80 not only interfered with adsorbtion, but that it apparently released adsorbed rotenone into solution when present in concentrations as low as 0.4 ppm. When added to 1 ppm Noxfish dispersions after 30 minutes of treatment with 30 ppm Nuchar Aqua A, this and higher concentrations of polysorbate 80 produced mortalities with typical rotenone-induced symptoms. No fish died in jars receiving 0.3 ppm polysorbate 80, no polysorbate 80, or polysorbate

80 alone up to 10 ppm. Toxicities corresponded to residual Noxfish concentrations ranging from 0.05 to 0.15 ppm for polysorbate 80 concentrations between 0.4 and 2.0 ppm.

Similar tests were conducted with five dishwashing detergents, two liquid laundry detergents and two liquid detergents designed for household cleaning. The laundry and household detergents and one of the dishwashing detergents did not affect rotenone adsorbtion at 10 ppm. The other four dishwashing detergents showed the same behavior as polysorbate 80, except that higher concentrations (2 to 5 ppm) were required for the apparent release of rotenone.

Stability and Introduction of Carbon Suspensions

After brief initial stirring, 30 ppm Nuchar Aqua A suspensions in laboratory jars decreased in apparent concentration in a roughly linear fashion to 13 ppm at the end of 24 hours, indicating an approximate half-life in suspension of 22 hours.

Two attempts were made to introduce carbon slurries into streams, using an unmodified siphon-drum assembly. In both instances, a measured amount of 10 per cent stock slurry was placed in the drum and diluted with an appropriate amount of water to give a 30 ppm concentration in the stream. Concentrations in the drum were 1.6 and 2.0 per cent, respectively. In the first attempt, the slurry in the drum tended to separate, causing a shifting rate of carbon introduction. Therefore, the slurry was agitated continuously by running it through a centrifugal pump during the second attempt.

In both instances, the results were highly unsatisfactory. The slurry, entering the stream at a point of relatively high velocity as a flow from a ½-inch plastic pipe held a few inches above the water, formed what appeared to be a uniform suspension in the stream, but it rapidly precipitated to the stream bottom. The suspension was barely detectable 500 feet downstream. Transparency measurements showed concentrations of less than 15 ppm at a distance of 100 feet, indicating a half-life in suspension of less than 5 minutes. At the end of the tests, the stream bottom was covered with an unsightly black deposit of carbon for a distance of about 200 feet. Within 3 days, however, this had dispersed downstream, evidently as bed load, and was scarcely detectable.

In an attempt to obtain a more stable suspension, an undiluted 10 per cent slurry was metered from a 13-gallon Mariotte bottle into the previously-mentioned mixing chamber and thence into the stream. Results indicated a precipitation loss of no more than 30 per cent of the carbon in the first 300 feet. It was, therefore, decided to go ahead with a field test of rotenone adsorbtion.

During the adsorbtion test on May 23, an undiluted 10 per cent

slurry was metered into the mixing chamber from the siphon drum. At first the slurry, having the consistency of a moderately thick milkshake, flowed at a rate much less than that predicted on the basis of more dilute slurries. However, by increasing the hydraulic head and using a double siphon, it was possible to obtain a mean initial in-stream concentration of 38 ppm. Downstream measurements, made under steady-state (plateau) conditions (Engstrom-Heg, 1971), indicated a half-life in suspension of 21 minutes, occurring at a point 660 feet downstream.

Rotenone Adsorbtion in the Stream

In the test on May 23, a complete kill of salmonid fish was obtained in the 200-foot section upstream from the carbon introduction point. At the end of the test, dead brook trout (*Salvelinus fontinalis*) and brown trout fry were abundant in the 100-foot section immediately downstream from the introduction point, but they were not observed beyond this. Live fry were observed 180 feet downstream. The rotenone concentration was apparently reduced to non-toxic levels in 2 to 6 minutes. Fish in liveboxes at 300, 400 and 500 feet survived.

Esthetic and Possible Environmental Effects

At the end of the test, the color of the substrate ranged from black at the point of carbon introduction to a dull gray 1,000 feet downstream. As in the previous tests, this discoloration dissipated over a period of a few days. The discolored zone appeared to be supporting a normal insect fauna, including simulid larvae, which are known to be rotenone-sensitive, and which are filter-feeders and therefore might ingest some of the carbon particles.

DISCUSSION

Activated carbon detoxifies a rotenone dispersion by adsorbing the rotenone rather than by breaking it down chemically. In situations where an equilibrium has been reached between adsorbed and unadsorbed rotenone, it is appropriate to plot adsorbtion isotherms based on Freundlich's equation, usually written as

$$(1) \qquad \frac{X}{M} = KC^{\frac{1}{n}}$$

where:

X = ppm of adsorbed chemical held by the carbon

C = ppm of residual unadsorbed chemical

M = ppm of carbon

K and n = parameters particular to the system

Corresponding values of $\frac{X}{M}$ and C are plotted on log-log paper, and estimates of $\frac{1}{n}$ and K are obtained from the slope and intercept at $C=1$ of the regression line. These parameters can then be used to compute a constant relating X and M for a particular desired value of C. At equilibrium, the carbon concentration needed to achieve a given concentration of chemical is directly proportional to the initial concentration of the chemical, minus the unadsorbed residue, and can be obtained by multiplying this value by the constant. Since the system is at equilibrium, time is not taken into consideration.

Where the system has not yet reached equilibrium, computations based on Equation (1) would not be valid, and some form of rate equation would be more appropriate. The data in Table 2 show clearly that equilibrium was not reached during the first 30 minutes of contact between 15 ppm Nuchar Aqua A and 1 ppm Noxfish. It appears likely that equilibrium is not reached within the range of times and concentrations useful in stream reclamation work. Accordingly, a rate equation was applied, having the form

$$(2) \quad T=\frac{\ln \frac{1}{C}(X+C)}{kM}$$

where:

k=a rate constant

T=the time needed to obtain residual concentration C

and the other symbols are in Equation (1)

This equation is patterned after a similar equation used to describe rotenone-potassium permanganate reactions (Engstrom-Heg, 1972). Carbon is treated as a reactant present in large excess and not significantly "used up" during the reaction time, and it is assumed that adsorbtion occurs at a rate proportional to the remaining concentration of unadsorbed rotenone, at least in the latter stages. Time required for detoxification to a given value is inversely proportional to the carbon concentration.

The carbon concentrations of 26, 31, 34 and 36 ppm for 1, 2, 3 and 4 ppm Noxfish, respectively, (Table 3) were obtained from Equation (2), using values of: $T=15$ muintes; $C=0.03$ ppm; and $K=0.009$. When tested, these values yielded final residual Noxfish concentrations between 0.03 and 0.056 ppm. The value of 35 ppm for 2 ppm Noxfish, which gave complete detoxification, was based on a value of $k=0.008$.

If one substitutes $C=0.03$ ppm and $K=0.008$ in Equation (2), one obtains

$$(3) \quad T=\frac{1n\ 33.3\ [N]}{0.008\ M}$$

where:

T=minutes

[N]=$C+X$, or the initial Noxfish concentration in ppm

At $T=15$ minutes, this gives values of M ranging from 23 ppm for 0.5 ppm to 41 ppm for 4 ppm Noxfish. In practical terms, this means that any rotenone concentration likely to be used in a stream reclamation can be adsorbed within a reasonable time by about 30 ppm of activated carbon. In most instances, exact calculations would be unnecessary.

Cohen et al. (1960), working on the assumption that they were dealing with a system at equilibrium, plotted apparent isotherms for pure rotenone and various commercial rotenone products treated with Nuchar Aqua A for a 30-minute period followed by glass-wool filtration. Initial rotenone concentrations were equivalent to 2 ppm Noxfish.

When $T=30$ minutes, $C+X=2$ ppm and $k=0.008$, Equation (2) can be used to generate a series of values of M and C which, when plotted on log-log paper, form an apparent isotherm (there is a slight curvature, but it would be obscured by small experimental errors) with parameters of $K=0.35$ and $\frac{1}{n}=0.37$, which falls within the range of values obtained by Cohen et al. It is easy to see, therefore, how data obtained at a constant time prior to equilibrium and treated in the standard manner could be interpreted as constituting an isotherm. Such an "isotherm", however, would be valid only for one value of $X+C$, and would predict values of M that would be much too low for low rotenone concentrations and too high for high rotenone concentrations (Table 4).

Table 4. Comparative Concentrations of Nuchar Aqua A Needed to Detoxify Noxfish to 0.03 ppm in 30 Minutes, As Computed by Rate Equation and by Isotherm Equation

Initial Noxfish concentration (ppm)	Computed carbon concentration (ppm)	
	By rate equation*	By isotherm equation§
0.5	11.5	4.9
1.0	14.5	10.1
2.0	17.5	20.6
3.0	19.5	31.0
4.0	20.5	41.5

* Equation (3).

§ Equation (1), using $K=0.35$ and $\frac{1}{n}=0.37$.

Results of the tests with polysorbate 80 and dishwashing detergents indicate clearly that rotenone-activated carbon systems should not be used in waters receiving appreciable amounts of domestic drainage, food-processing wastes or other effluents likely to contain non-ionic surfactants.

Preparation of a 10 per cent activated carbon slurry in a 55-gallon drum is an easy and relatively tidy procedure, and the resulting slurry is quite stable and uniform. More dilute slurries separate out unless constantly stirred. The transition from a 10 per cent slurry in a drum to a relatively stable 30 ppm suspension in stream water is more difficult. The siphon-drum assembly, designed for use with potassium permanganate solutions, was barely satisfactory for handling the viscous slurry. Constant attention was needed to maintain anything resembling a constant flow. Modifications are planned that may improve its performance. However, it seems likely that any of several models of peristaltic tube pumps now on the market would be superior to a gravity device for moving the carbon from the drum to the stream at a constant rate. These, of course, require a power source and would not be usable at all possible locations.

The failure of normal stream turbulence to provide sufficient mixing to form a stable suspension is rather surprising. However, there was no question that the 10 per cent slurry needed a several-fold dilution and mixing with stream water in a mixing chamber before it would disperse properly in the stream. Again it seems probable that this result could be obtained with any of a variety of rotary or Venturi-type mixing devices, and that some of these might yield more satisfactory dispersions than the device used.

At first glance, it might appear that the rate of adsorbtion in the stream test (0.8 ppm Noxfish, 38 ppm carbon and non-toxic conditions in 3 to 6 minutes) was more rapid than would be predicted by Equation (3). Equation (3), however, is not fully applicable because the rotenone treatment was limited to 90 minutes. The 90-minute EC-50 for brown trout is approximately 0.085 ppm Noxfish (Loeb and Engstrom-Heg, 1971) rather than 0.03 ppm. Use of this value and a rate constant of $k=0.021$ (based on time for adsorbtion to this level) in Equation (2) yields a detoxification time of 2.9 minutes. It appears likely that, if rotenone treatment had continued for several hours, mortality would have extended downstream about 360 feet, corresponding to a contact time of 13 minutes at a mean carbon concentration of 32 ppm.

Adsorption on activated carbon can be regarded as a viable alternative to potassium permanganate treatment for eliminating rotenone toxicity from running water. The method, however, appears to be restricted to unpolluted, relatively small streams. The volume of stock preparation that must be handled is about five times that needed for

an equally rapid potassium permanganate detoxification. There is relatively little difference between the two methods with regard to ease of application and probably with regard to ecological and esthetic impact. The black deposit left on the stream bottom is not attractive, but it disappears rather rapidly. It is possible that some benthic filter-feeders or net-spinners might ingest carbon particles, but the probability of deleterious effects appears to be low, since adsorbed rotenone is released very slowly under most conditions and would probably be acted on by the animal's digestive juices. Since excess amounts of carbon are not toxic, rates of application need not be controlled as precisely as with potassium permanganate. Carbon adsorbtion would be the method of choice in any situation in which there were objections to the use of potassium permanganate, and quite possibly in situations where humic acids or other colloidal organic materials create a high potassium permanganate demand.

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INCIDENCE AND DISTRIBUTION OF MANGE MITES IN FOXES IN NEW YORK[1]

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ABSTRACT

The sarcoptic mange mite (*Sarcoptes scabiei*) was found on 47 (7.4 per cent) of 638 red foxes trapped during rabies control operations, but none of these mites was found on 209 gray foxes taken during the same trapping operations. Another mite (*Demodex* sp.) was found on 71 (11.1 per cent) and two (0.96 per cent) of the same groups, respectively. The ear mite (*Otodectes cynotis*) was found on 35 (12.2 per cent) of 287 of the red foxes, but it was absent on the 39 gray foxes examined for this parasite. In addition, 123 red foxes, found dead or dying and submitted for examination, were found to be infested with sarcoptic mange mites.

Pryer (1965) in Pennsylvania and Trainer and Hale (1969) in Wisconsin reported on the occurrence and importance of sarcoptic mange among wild red foxes. Parks (1968) reported that sarcoptic mange had become quite prevalent in New York State and had effectively reduced red fox abundance to the point that some areas seemed void of the species. The pathology of sarcoptic mange was described by Trainer and Hale (1969) and Stone et al. (1972), and Stone also described its host specificity. Beyond this, little has been reported on the impact of infestations of the sarcoptic mite (*Sarcoptes scabiei*) and other mites such as *Otodectes cynotis* and *Demodex* sp. as morbidity or mortality factors in wild red fox populations in New York. The objectives of the present study were to further assess the incidence of sarcoptic mange infestations on red foxes in the State and to make some estimate of the otodectic and demodectic infestations occurring on red foxes and gray foxes.

PROCEDURE

During the years 1970 and 1971, 638 red foxes (*Vulpes fulva*) and 209 gray foxes (*Urocyon cinereoargenteus*) trapped during rabies control operations in 13 counties were examined at the Wildlife Research

[1]A contribution of Federal Aid in Fish and Wildlife Restoration Project W-35-R.

Laboratory at Delmar (N.Y.) for the presence of mange mites. An additional 123 red foxes, from 30 counties, that had been found dead or dying of suspected sarcoptic mange were submitted for examination by regional wildlife managers, conservation officers and the public. The specimens came from throughout the State, 36 of the 62 counties being represented.

Skin samples were removed from the snout and tibial regions of each healthy-appearing fox, and random skin samples from the body as a whole were removed from those with obvious clinical signs of sarcoptic mange. Also, scrapings of ear tissue were removed from 287 red foxes to determine the occurrence of otodectic mites. All tissue samples were placed in 70 per cent ethyl alcohol until they could be mounted in lactophenol for microscopic examination.

RESULTS

Mites of three genera were found on the foxes examined. These were *Sarcoptes scabiei* (sarcoptic mange), *Demodex* sp. (red mange of dogs) and *Otodectes cynotis* (otodectic mange). Of the 638 trapped red foxes, 47 (7.4 per cent) were infested with *S. scabiei* (Table 1), but none of these mites was found on the 209 trapped gray foxes. *Demodex* sp. mites were found on 71 (11.1 per cent) and two (0.96 per cent) of the same groups, respectively. Ear mites (*O. cynotis*) were found on 35 (12.2 per cent) of the 287 red foxes examined for this parasite, but on none of the 39 gray foxes examined for it. With respect to the 123 red foxes that were found dead or dying, all were determined to be positive for sarcoptic mange; their distribution is shown in Figure 1. All findings were confirmed by microscopic examination.

Table 1. Distribution, by County, of the Trapped Red Foxes Examined in New York During 1970 and 1971, and the Profortion Infested With Sarcoptic Mange Mites

County	Number examined	Infested with sarcoptic mange mites	
		Number	Per cent
Clinton	18	0	0.0
Franklin	109	4	3.6
Fulton	39	1	2.5
Herkimer	4	0	0.0
Jefferson	79	4	5.0
Lewis	93	8	8.6
Niagara	18	2	11.0
Oneida	6	2	33.3
Oswego	52	5	9.6
St. Lawrence	85	11	12.9
Seneca	32	3	9.3
Suffolk	28	2	7.1
Wayne	75	5	6.0
Total	638	47	7.4

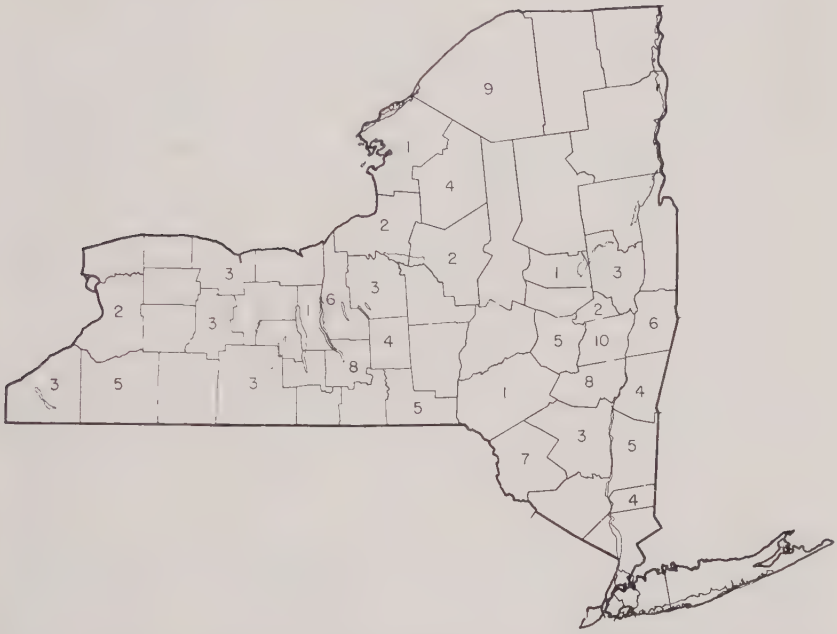

Figure 1. Distribution of 123 red foxes found dead or dying of suspected sarcoptic mange during 1970 and 1971.

DISCUSSION

It is apparent from this study that infestations of the mites *S. scabiei*, *Demodex* sp. and *O. cynotis* are widespread in red fox populations throughout New York. The importance of *Demodex* sp. and *O. cynotis* as fox morbidity and mortality factors is yet unclear. However, the study strongly suggests that sarcoptic mange is an important mortality factor for the red fox. Also, red foxes may be a constant reservoir of *S. scabiei* and *O. cynotis* for the domestic dog.

The data corroborate work of Stone et al. (1972) who found the red fox to be highly susceptible to sarcoptic mange while the gray fox seemed largely immune. They found sarcoptic mange infestations in red foxes to be fatal in 2 to 4 months. On the other hand, when they experimentally attempted to infest gray foxes with low dosages of *S. scabiei* var. *canis*, they were unsuccessful. When contaminating dosages were increased to thousands of mites per fox, only transitory infestations were observed.

Little is known concerning the occurrence or pathogenicity of demodectic mites in wild foxes. Riley (1921), in summarizing the literature on parasites of the red fox, reported that *Demodex* had rarely been found. In the present study, no significant pathology was found to be

associated with infestations of *Demodex* sp. on either red foxes or gray foxes.

Infestations of the ear mite (*O. cynotis*) did not appear to cause any serious morbidity in the red foxes examined, but this parasite has been reported to cause rabiform and epileptiform signs in dogs and cats (Sweatman, 1958). Zeh (1973) found this mite on six of 36 red foxes from New York that he examined.

Based on the data from all foxes examined, sarcoptic mange was found to occur in 34 of the 36 counties represented during the years 1970 and 1971. Sarcoptic mange infestations were found on red foxes in all months of the year. While infestations were not associated with any particular season, the number of mangy red foxes submitted increased in July and August.

Trappers reported that foxes severely infested with sarcoptic mange were rarely, if ever, trapped even though such animals were seen dead or dying in the trapping area. This is possible due to the debility and extensive behavioral changes associated with sarcoptic mange. It might well indicate that the incidence recorded for the trapped foxes represents an underestimate of the proportion of the red fox population actually infested with sarcoptic mites. The incidence of detected sarcoptic mange was minimal because mite numbers are low during the early stages of infestation and may escape detection. Also, a red fox with sarcoptic mange usually succumbs within 4 months. Thus, the yearly rate of mortality due to mange among red foxes in New York probably far exceeds the 7.4 per cent incidence of sarcoptic mites found in this study.

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SOME PATHOLOGICAL CONDITIONS OF WILDLIFE KEPT IN CAPTIVITY[1]

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ABSTRACT

Cases are reported in which pathological conditions in captive wildlife were linked to stress, human disturbance or the conditions under which they were held. There is need for standards for the penning, feeding and care of such animals, as well as for ensuring that wildlife transported from one area to another is disease-free.

Wildlife may be kept in captivity for various reasons. Where this is done without suitable facilities or proper attention to the needs of the animal, pathological conditions can result. Following are several instances of this sort that have been noted in animals submitted to the Wildlife Research Laboratory at Delmar (N.Y.) Six cases involved white-tailed deer, one a harbor seal and one a wild canid of the type described by Silver and Silver (1969).

In three of the cases, the conditions probably resulted from stress and disturbance by humans.

A 2-year-old female deer was found dead in her pen at a small zoo on June 18, 1970 with a complete prolapse of the uterus and prolapse of the rectum, although she was otherwise in good condition with ample subcutaneous, abdominal and preirenal fat. This doe had dropped a single dead fawn on June 17, which had been thrown away by the zoo keeper. For several days previously, a bulldozer had been at work just outside her pen. Williams (1909) stated that a contributory cause of uterine prolapse is often the stress of close confinement and overfeeding. The disorder is rare in pastured cattle but common in stabled dairy cows. Holland and Knox (1967) found vaginal prolapses in 27 of 150 Hereford cows held in stables but none among 400 that were free-ranging. The two herds were gentically very similar. The prolapse of the uterus of the doe in the present case was attributed, at least in part, to the stress caused by the disturbance of the bulldozing operation.

A 3-day-old male fawn was found dead in its pen on June 1, 1971. It weighed 5.2 pounds and had apparently been neglected by its mother;

[1]A contribution of Federal Aid in Fish and Wildlife Restoration Project W-35-R.

there was no evidence of milk in the alimentary canal. Only soil and small stones were found in the stomach and intestines, the musculature was pale and the animal had mild enteritis and lobular pneumonia. During the three days following the fawn's birth, there was extensive human disturbance of the pen. Vandals climbed the wire fences and sprayed them and the hay from spray paint cans. This disturbance may have resulted in the abandonment of the fawn. Severinghaus and Cheatum (1956) indicated that they were not familiar with any record of a doe abandoning a living fawn. Abandonment of young is, at most, a very rare occurrence and probably would not have happened in this case without the stress of human disturbance.

During the week of June 14, 1970, two harbor seals were collected along the coast of Maine for transfer to the Syracuse Zoo. They were transported in small crates atop an automobile. One, a young male, died in transit and was brought to the Laboratory at Delmar where the cause of death was determined to be hemorrhagic septicemia (shipping fever of cattle) the causative organism of which is *Pasteurella multocida.* This organism is found in the upper respiratory tracts of either normal or carrier animals; both theories were presented by Rosen (1970). It is an invader during periods of physiological stress or secondary to another infection. The ensuing infection, when acute, is hemorrhagic septicemia. Capture and transport of the young seal may have caused sufficient stress to result in the fatal septicemia. It would be interesting to know whether the *P. multocida* present would have caused death if the seal had not been taken and placed under stress.

Another group of cases are related to the conditions of captivity of the affected animals. All too often, wild animals are taken captive and held without proper attention to pen facilities, nutrition or special needs of the animal stemming from behavioral patterns.

In June 1971, a 3-day-old male fawn died suddenly in his pen. The umbilicus was moist, and there was a black tarry fluid accumulating on the hair in this region. At necropsy, gas bubbles could be seen in the blood vessels, liver tissue and kidneys. The area of umbilical attachment to the liver was highly inflamed, and the umbilicus was the probable route of infection. Liver cultures grew *Clostridium chauvei,* the causative agent of blackleg. The deer's pen at this time was barren of grass and quite muddy, providing ideal conditions for the anaerobic *Clostridium.* Plant growth and proper drainage would have minimized chances for the acquisition of blackleg.

On September 23, 1971, an adult doe was examined after being found dead in her pen (25′ x 40′) at a county fairgrounds. Necropsy revealed that the doe had received a massive beating from the buck with which she was penned. Hematomas were present over most of the musculature, and there were deep muscle tears caused by the antlered buck,

even though the skin was not actually torn. There was a puncture wound in one side of the thorax which penetrated the thoracic wall, and the lung had been lacerated. This kind of catastrophe can be expected during the rutting period when does and bucks are held together in pens that are too small and in which the doe has no avenue for escape.

In February 1972, a female fawn was confiscated from an individual who was keeping it without a permit. The fawn (7–9 months old) was markedly stunted and had a round weight of only 37½ pounds. Female fawns about 6 months old from the poor range of the central Adirondacks have an average dressed weight of 53 pounds (Severinghaus, 1955). It is probable that this fawn's diet during the critical first few months of life was inadequate, as is often the case of fawns that are kept as pets. At the Laboratory, the fawn gained on the diet provided, and in April it weighed approximately 50 pounds and was growing somewhat in stature.

A female fawn was picked up at Cochecton Center in Sullivan County in March of 1972. Several days earlier it had been seen in the same locality feebly moving about in a field, but attempts to capture it had been unsuccessful. The fawn died the day after it was picked up and was found to be small and severely emaciated, having a round weight of only 24 pounds. The condition of the teeth indicated an age of 6 months, according to the method of Severinghaus (1949). A low-grade

Figure 1. Front foot of fawn showing dew claws and hooves greatly elongated as a result of too-close confinement.

peritonitis was present. Also, a No. 6 birdshot was found well encapsulated in the musclature of one hind leg. The dew claws and hooves on both front and hind feet were greatly elongated and showed virtually no wear (Figure 1), and pieces of oat-straw bedding were found in crevices of the hooves. This fawn had probably been kept in captivity and recently released to the wild. It had perhaps been wounded by birdshot in the late summer or early fall and kept in a small pen on a highly inadequate diet until shortly before it was found. The greatly overgrown hooves indicate that it had done practically no moving about. Hediger (1964) described a number of cases illustrating the problem of hoof overgrowth in captive animals. A severe calcium deficiency suggested that the fawn was considerably older than the aging technique used indicated it to be.

In addition to pathological conditions related to human disturbance and the conditions of captivity, other problems resulting in one way or another from captivity have been noted. One involved an adult male wild canid that was shot in February 1972 by a conservation officer because of its strange behavior. Examination revealed a 10-inch metal choke-chain buried in the tissues of the neck (Figure 2). The chain had been put on when the animal was a small pup, and the animal had either been released to the wild or escaped still wearing the collar. As it grew, the chain cut into the skin of the neck and throat. On the throat, the epidermus had healed over the chain, leaving open wounds

Figure 2. Choke-chain embedded in neck of wild canid.

where the chain entered and left. The animal was in good flesh. Its strange behavior was probably due to pressure from the chain on the spinal column and trachea which was compressed.

Another problem concerns the spread of disease. At the time the seals were collected in Maine (as noted earlier), a number of cormorants were also collected for transfer to the Syracuse Zoo. At the same time, dead eider ducks were encountered in the same vicinity, and several were picked up and brought to the Laboratory at Delmar. The eiders were determined to have died of fowl cholera, the causative organism of which (*P. multocida*) is the same as that which caused the hemorrhagic septicemia in the seal that died in transit. Transfer of the seals and cormorants from a locality in the midst of a fowl cholera epizootic to another area points up the possibility of mechanically transferring wildlife diseases from one area to another. In this case, the contaminated crates, ponds, etc. were disinfected, and the cormorants (for lack of isolation facilities) were destroyed and their carcasses burned. A fowl cholera epizootic at the Zoo may thus have been averted. The possibility of disease transfer always exists when captive animals (whether native or exotic) are moved from one place to another.

During the summer of 1971, a case of cutaneous streptothricosis was found in a captive fawn in Columbia County (Stone, 1972). It it not known whether the infection was wild-acquired or acquired from association with domestic animals. If the infection had been acquired in captivity and the fawn had been released, it could have carried the disease to wild deer in the area.

The instances reported point up the need for regulations concerning wildlife held in captivity. Present law in New York requires only that a person obtain a permit from the Department of Environmental Conservation to keep most native wildlife and endangered species in captivity. Standards are needed for the penning, feeding and care of such animals, as well as for ensuring that wildlife transported from one area to another is disease-free.

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MARKING TROUT BY CARBON INJECTION[1]

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ABSTRACT

Graphite and lampblack, injected into the upper and lower jaws of fingerling brown trout, were retained as visible marks for from several months to over a year, depending on the formulation used. Best results were obtained with a 45 per cent alkaline water suspension of graphite, emulsified with polysorbate 80 and injected into the lower jaw with a #20 needle. Fading occurs through overgrowth of opaque tissue and probably through transport away from the marked area via the lymphatic system. Dissection of the jaws showed residual carbon at the end of 2 years. The marks are non-toxic and non-mutilating.

Trout and other fish may be marked by injecting various colored substances into the upper or lower jaw with a hypodermic needle. When such marks persist over appreciable periods, they are highly satisfactory in that they do not mutilate or handicap the fish, as is often the case with fin clipping and tagging, and that they are usually not conspicuous enough to attract the attention of predators. More than 150 substances, mainly dyes, have been tested at the Fish Laboratory at Livingston Manor (N.Y.) as injection marking materials. Three dyes imparted marks that lasted over a year, and several others were satisfactory short-term marks with durations of 2 to several months. This work has been reported by Kelly and Loeb (1964), Kelly (1967a, 1967b, 1967c), Loeb (1968) and Loeb and Kelly (1969).

When a dye is injected into an animal that may become a food product, it is regarded as a food additive and, as such, is subject to regulation by the U.S. Food and Drug Administration. This is true even though the amount injected may be minute, and despite the fact that most persons are rather unlikely to eat the bony portion of a fish's head. Since dye marks do fade, and since it is probable that fading usually involves transport of dye to and through other parts of the body, this concern over toxicity of dye substances is not totally without logic. The most successful dyes are coal-tar derivatives, compounds of heavy metals (e.g., hydrated chromium oxide) or both (e.g., National Fast Blue 8GXM) and are substances that are not likely to be used as additives in mass preparation of food. Since many substances in these categories are

[1]A contribution of Federal Aid in Fish and Wildlife Restoration Project F-9-R.

either toxic or carcinogenic, extensive tests would be required for their clearance, requiring a greater expenditure of funds and effort than would be justified for use in fish marking. Use of such dyes, therefore, is likely to remain confined to experimental studies in which the fish are not available for public harvest.

Elemental carbon in its various forms is ubiquitous in the environment of civilized man and is, for all practical purposes, biologically inert. Its presence as a minor ingredient in foods is generally ignored and cannot meet with any reasonable objection. As an injection mark, it should have most of the advantages of a dye, without the disadvantages.

Kelly (1967a) reported a 4-month retention at the 50 per cent level for India ink injected into the jaws of fingerling brown trout (*Salmo trutta*). Although this result was only moderately promising, further tests with other forms of carbon were started in 1969.

METHODS

In April 1969, two lots of fingerling brown trout (Lots 1 and 2) were marked by injecting carbon Formulations 1 and 2 (Table 1) into the mandibles and maxillaries. Formulation 1 was injected with a #23 needle, and Formulation 2 with a #20 needle. The needle was inserted parallel to the bone, and the carbon was injected during withdrawal as described by Kelly and Loeb (1964).

In March 1970, three more lots of brown trout (Lots 3, 4 and 5) were marked. Lot 3 was marked on both maxillaries and mandibles with Formulation 3, using #20 and #21 needles. Lot 4 was marked on the left maxillary and mandible with Formulation 4, using a #20 needle. Lot 5 was tattooed at the base of the left pectoral and pelvic fins with Formulation 3 and at the base of the right pectoral and pelvic fins with

Table 1. Composition (in percentage by weight) of the Carbon Formulations Used

Formulation	Carbon		Emulsifier		Sodium hydroxide (per cent)	Water (per cent)
	Type	Per cent	Type	Per cent		
1	Lamp black, Will (petroleum base)	25.00	Marasperse†	1.25	..	73.75
2	Graphite "Lockmate"*	30.00	Polysorbate 80 "Eazy-flo"‡	1.00	..	69.00
3	Graphite Asbury 5530§	48.42	Lomar D°	3.06	0.10	48.42
4	Graphite Asbury 5530§	43.96	Polysorbate 80 "Eazy-flo"‡	2.20	0.11	53.73

* Product of Joseph Dixon Crucible Co., Jersey City, N.J.
§ Product of Asbury Graphite Mills, Asbury, N.J.
† Product of American Can Co., Neenah, Wis.
‡ Product of American Food Laboratories, Brooklyn, N.Y.
° Product of NOPCO Chemical Division, Diamond Shamrock Chemical Co., Newark, N.J.

Formulation 4. Tattoos were applied with a commercial battery-powered tattooing needle over the bones of the pectoral and pelvic girdles. All fish were held in laboratory tanks at 58° F. and examined at intervals for mark retention.

RESULTS

Lots 1, 2, 3 and 4 all retained easily-recognizable marks for several months as shown in Table 2. The tattoos applied to Lot 5 showed re-

TABLE 2. DURATION OF CARBON-INJECTION MARKS IN FINGERLING BROWN TROUT

Fish used			Carbon formulation	Location of mark	Retention to 12 months (per cent)	Estimated half-life of mark		
Lot	Number	Initial mean weight (grams)				Time (months)*	Mean weight (grams)	Weight increase (per cent)§
1	25	76	1	mandible	89	20.3†	815†	972
				maxillary	41	11.2‡	410‡	439
2	25	74	2	mandible	87	15.6‡	605‡	718
				maxillary	88	16.5‡	645‡	772
3	25	81	3	mandible	57	12.8‡	556‡	586
				maxillary	50	12.0	485	499
4	24	81	4	mandible	92	18.6‡	845‡	943
				maxillary	92	16.5‡	755‡	832

* At 50 per cent retention.
§ From marking to 50 per cent retention.
† Extrapolated value; retention was 61 per cent at 18 months and 709 grams.
‡ Based on linear interpolation.

tention of less than 50 per cent at the end of 5 months. Microscopic examination of dissected jaws from fish in Lot 4 at the end of 2 years showed that small amounts of residual graphite were present in all jaws, whether or not the mark was visible from the outside. The graphite appeared to be confined to the periosteal tissue, where it formed thin, irregular lines of granules as if contained in a delicate vascular structure.

DISCUSSION

It is evident that the best results were obtained with graphite, emulsified with a small amount of the common food additive, polysorbate 80, in an alkaline solution and injected in the mandible with a #20 needle. McLean and Urist (1961), discussing the skeletal physiology of mammals, noted that carbon granules from injected India ink can be observed in the lympathic vessels of the periosteum. It appears likely that fading of carbon marks occurs in part through the transport of particles away from the marking site via these vessels. Perhaps the residual graphite is that which remains in lympathic vessels clogged by large particles. Another obvious cause of fading is the overgrowth of opaque tissue. Fading occurs more rapidly in the upper jaw than in the lower, largely because of the larger amount of masking pigmentation. There ap-

pears to be no logical reason for better retention of graphite emulsified with polysorbate 80 than with Lomar D. At any rate, polysorbate 80, since it is effective, safe and easily available, is the emulsifier of choice.

It seems unlikely that the exact composition of the formulation is very critical. The important thing is that the carbon be injected as a thick, uniform slurry. Variation has been observed between the wetting properties of different lots of graphite sold by the same manufacturer. If a mixture prepared in accordance with Formulation 4 were not sufficiently liquid to pass through the needle, it would be necessary to add water until the right texture was obtained. It seems probable that the best results would be obtained by using as coarse a grade of graphite as will pass easily through the needle. Surface area decreases with increased particle size, facilitating wetting and making possible a more concentrated suspension. At the same time, there is good reason to think that larger particles might be retained longer at the marking site.

In general, it may be stated that the method is satisfactory for marking rapidly-growing trout for periods of up to a year, or for longer periods in cases where it is possible to dissect the jaws. Longer retention might be obtained with slower-growing fish as noted for dyes by Kelly (1967b) and Loeb (1968).

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GENERAL NOTES

FOOD HABITS OF THE COYOTE IN THE ADIRONDACKS[1]

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Over the past 30 years, as described by Severinghaus (1974), there has become established in the Adirondack region of New York a population of animals that fit the general description of the eastern coyote (*Canis latrans* var.). Information on the food habits of these animals is of interest.

From 1956 to 1961, coyote scats were collected is the Adirondack region by State trappers and other Conservation Department personnel and sent to the author for examination. The collections were made primarily in the central part of the region and represented all seasons of the year. Analyses of the 1,500 scats examined are summarized in Table 1.

The snowshoe hare was the primary prey species. An astonishingly high incidence of red squirrels contributed to the food during these years. However, a considerable variety of foods were taken. As with the red fox and other carnivores, seasonal availability is important in determining the nature of the food as evidenced by the incidence of fruit.

Remains of deer were found in a large proportion of the scats examined. It is well known that coyotes can and do kill deer, particularly during periods of deep snow when the deer are hampered in their travels. Also, fawns are vulnerable to predation during their early life as evidenced by the occurrence of their small hoofs in some of the scats examined. However, it is felt that to a large degree the source of the deer remains identified was actually carrion. Each year many antlerless deer are shot and left in the woods by hunters, and bucks are shot which are not recovered. Deer are also shot illegaly out of season. But the major source of carrion probably was winter losses, chiefly from starvation, which occurred every year and in some years were heavy. Such carcasses provide food for coyotes, as well as for foxes and bears. The amount of such food was substantial in relation to the sparse coyote population and the wide area covered by individual animals.

During the course of the work, efforts were made to obtain material that would be representative of different seasons of the year. Information on coyote behavior was being gathered by State trappers who were assigned, as they encountered them, to follow the tracks of coyotes in the snow and record their activities. These trappers were instructed to pick up scats that, because they were on the snow, were obviously of winter origin. Analyses of the 240 such specimens are summarized in Table 2. The variety of foods was rather limited, with deer and snowshoe hare predominating.

Collections representative of the summer season were made in two localities: (1) certain woodsroads in the vicinity of Shattuck Clearing and on the Huntington Forest near Newcomb in Essex County; and (2) certain woodsroads in the vicinity of the "Plains" on the South Branch of the Moose River in central Hamilton County. These routes were traversed during the spring and cleaned of all droppings. Then, at various times throughout the summer and early fall, the coyote scats deposited along them were collected. Analyses of the 616 specimens examined are summarized in Table 3.

In this material, the incidence of snowshoe hares remained high while that of deer was markedly less than during the winter. The seasonal importance of fruits and insects was evident. Birds, especially grouse, and amphibians and reptiles had been taken.

In addition, the seasonal food habits of the coyote were studied on an area between Newcomb and Minerva in Essex County. An old railroad bed and a woodsroad (fire trail) were selected for the collection of scats. The two routes were about a mile apart. The railroad track passed through a large muskrat, duck and beaver

[1]A contribution of Federal Aid in Fish and Wildlife Restoration Project W-84-R.

Table 1. Analyses of 1,500 Coyote Scats Collected in the Adirondack Region During All Seasons From 1956 to 1961

Food	Number of occurrences		Percentage frequency	
Mammals	1,176		78.4	
Snowshoe hare		608		40.5
Deer		397		26.5
Red squirrel		159		10.6
Deer mouse		55		3.7
Field mouse		53		3.5
Muskrat		50		3.3
Short-tailed shrew		46		3.1
Chipmunk		45		3.0
Cottontail rabbit		38		2.5
Red-backed mouse		19		1.3
Woodchuck		15		1.0
Flying squirrel		12		0.8
Porcupine		10		0.7
Red fox		6		0.4
Jumping mouse (*Napaeozapus*)		5		0.3
Long-tailed shrew		5		0.3
Beaver		4		0.3
Skunk		3		0.2
Gray squirrel		2		0.1
Lemming mouse (*Synaptomys*)		2		0.1
Hairy-tailed mole		2		0.1
Raccoon		2		0.1
Bobcat		1		0.1
Bear (claws of small cub)		1		0.1
Fruit	315		21.0	
Raspberry and blackberry		234		15.6
Blueberry		61		4.1
Wild cherry		25		1.7
Shadberry		12		0.8
Apple		6		0.4
Silky cornel		5		0.3
Wild sarsaparilla		4		0.3
Partridgeberry		3		0.2
Mayflower		3		0.2
Strawberry		2		0.1
Mountain ash		2		0.1
Chokeberry		2		0.1
Nannyberry		1		0.1
Gooseberry		1		0.1
Insects	155		10.3	
Grasshopper		114		7.6
Beetle		38		2.5
Cricket		6		0.4
Undetermined		35		2.3
Birds	54		3.6	
Grouse		30		2.0
Bluejay		2		0.1
Thrush		2		0.1
Undetermined		20		1.3
Amphibians	21		1.4	
Reptiles	21		1.4	
Beechnuts	13		0.9	
Green grass	132		8.8	
Mosses and ferns	82		5.5	
Livestock	10		0.7	
Poultry		4		0.3
Sheep		4		0.3
Cattle		2		0.1

area. The woodsroad passed through a conifer plantation and over an open hardwood ridge. Collections were made in June, July, August and early October. On each visit, a determined effort was made to clear the collection route of every scat so that those collected on the next visit would represent the interven-

TABLE 2. ANALYSES OF 240 COYOTE SCATS COLLECTED IN THE CENTRAL ADIRONDACKS DURING THE WINTER (NOVEMBER THROUGH MARCH) FROM 1956 TO 1961

Food	Number of occurrences	Percentage frequency
Mammals	178	74.2
Snowshoe hare	80	33.3
Deer	94	39.2
Red squirrel	19	7.9
Field mouse	6	2.5
Muskrat	7	2.9
Short-tailed shrew	2	0.8
Chipmunk	2	0.8
Flying squirrel	1	0.4
Jumping mouse (*Napaeozapus*)	2	0.8
Gray squirrel	1	0.4
Bear (claws of small cub)	1	0.4
Fruit	10	4.2
Raspberry and blackberry	7	2.9
Apple	2	0.8
Partridgeberry	2	0.8
Insects	3	1.3
Birds	4	1.7
Green grass	17	7.1
Mosses and ferns	6	2.5

TABLE 3. ANALYSES OF 616 COYOTE SCATS COLLECTED IN THE CENTRAL ADIRONDACKS* DURING THE SUMMER AND EARLY FALL (JULY THROUGH SEPTEMBER) FROM 1956 TO 1961

Food	Number of occurrences	Percentage frequency
Mammals	430	69.8
Snowshoe hare	242	39.3
Deer	108	17.5
Red squirrel	64	10.4
Deer mouse	17	2.8
Field mouse	18	2.9
Muskrat	35	5.7
Short-tailed shrew	14	2.3
Chipmunk	11	1.8
Red-backed mouse	4	0.6
Woodchuck	4	0.6
Flying squirrel	5	0.8
Porcupine	8	1.3
Red Fox	2	0.3
Beaver	2	0.3
Fruit	145	23.5
Raspberry and blackberry	104	16.9
Blueberry	41	6.7
Wild cherry	16	2.6
Shadberry	4	0.6
Apple	3	0.5
Silky cornel	2	0.3
Insects	63	10.2
Grasshopper	48	7.8
Beetle	9	1.5
Cricket	5	0.8
Undetermined	3	0.5
Birds	31	5.0
Grouse	18	2.9
Bluejay	2	0.3
Thrush	2	0.3
Undetermined	9	1.5
Amphibians	16	2.6
Reptiles	10	1.6
Beechnuts	3	0.5
Green grass	41	6.7
Mosses and ferns	12	1.9

* Collection routes in vicinity of Shattuck Clearing and in Huntington Forest.

Table 4. Analyses of 525 Coyote Scats Collected in the Central Adirondacks* During June, July, August and October From 1956 to 1961

Food	Winter specimens§: June (218)†		Summer and early fall specimens							
			July (67)†		August (190)†		October (50)†		Total summer and early fall (307)†	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
Mammals	203	93.1	56	83.6	161	84.7	39	78.0	256	83.4
Snowshoe hare	122	56.0	25	37.3	99	52.1	19	38.0	143	46.6
Deer	68	31.2	16	23.9	14	7.4	8	16.0	38	12.4
Red squirrel	9	4.1	5	7.5	13	6.8	11	22.0	29	9.4
Deer mouse	..	..	1	1.5	2	1.1	1	2.0	4	1.3
Field mouse	1	0.5	..	..	4	2.1	..	..	4	1.3
Muskrat	4	1.8	1	1.5	2	1.1	1	2.0	4	1.3
Short-tailed shrew	1	0.5	3	4.5	1	0.5	1	2.0	5	1.6
Chipmunk	3	1.4	3	4.5	7	3.7	1	2.0	11	3.6
Red-backed mouse	4	1.8	1	1.5	2	1.1	1	2.0	4	1.3
Woodchuck	1	0.5	..	..	2	1.1	..	..	2	0.7
Flying squirrel	4	1.8	..	..	1	0.5	..	..	1	0.3
Porcupine	2	0.9	..	..	..	..	..	..	..	..
Red Fox	1	0.5	1	1.5	2	1.1	..	..	3	1.0
Long-tailed shrew	..	..	1	1.5	..	..	1	2.0	2	0.7
Beaver	..	..	1	1.5	1	0.5	..	..	2	0.7
Raccoon	..	..	..	..	1	0.5	..	..	1	0.3
Fruit	..	..	9	13.4	35	18.4	15	30.0	59	19.2
Raspberry and blackberry	..	..	4	6.0	24	12.6	12	24.0	40	13.0
Blueberry	..	..	1	1.5	7	3.7	2	4.0	10	3.3
Wild cherry	..	..	..	..	2	1.1	..	..	2	0.7
Shadberry	..	..	5	7.5	3	1.6	..	..	8	2.6
Silky cornel	..	..	1	1.5	2	1.1	..	..	3	1.0
Wild sarsaparilla	..	..	..	..	1	0.5	1	2.0	2	0.7
Strawberry	..	..	..	..	1	0 5	1	2.0	2	0.7
Mountain ash	..	..	..	..	1	0.5	1	2.0	2	0.7
Insects	2	0.9	3	4.5	22	11.6	2	4.0	27	8.8
Birds	9	4.1	3	4.5	3	1.6	4	8.0	10	3.3
Grouse	5	2.3	3	4.5	2	1.1	2	4.0	7	2.3
Undetermined	4	1.8	..	..	1	0.5	2	4.0	3	1.0
Amphibians	2	0.9	1	1.5	1	0.5	1	2.0	3	1.0
Reptiles	4	1.8	1	1.5	4	2.1	2	4.0	7	2.3
Green grass	6	2.8	1	1.5	12	6.3	14	28.0	27	8.8
Mosses and ferns	3	1.4	2	3.0	3	1.6	7	14.0	12	3.9

* Collection routes between Newcomb and Minerva.
§ Scats collected in June considered to have been largely winter specimens (see text).
† Figures in parentheses are number of scats collected each month.

ing interval. Analyses of the 525 scats examined are summarized according to month of collection in Table 4.

The scats collected during June were largely winter specimens as indicated by the winter pelage of deer and hare contained in them. This was also evidenced by the lack of any fruits in this group. The snowshoe hare continued to be the principal food throughout the summer, while the incidence of deer dropped to a low in August. Specimens collected from July on again reflected the seasonal availability and use of fruits. Birds, amphibians and reptiles occurred in small numbers in all months.

In summary, these data show the snowshoe hare to have been the primary prey species of the coyote in the Adirondacks throughout the year. There was a high incidence of deer remains in the scats examined, particularly those representing the late fall, winter and spring seasons. However, it is felt that to a large degree this reflected scavanging on carcasses of hunter-killed and winter-killed deer rather than direct predation. A variety of other small mammals were taken, especially during the warmer months, and a few birds, amphibians and reptiles were recorded. From mid-summer to early fall, fruit provided a substantial share of the diet.

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INFESTATIONS OF SARCOPTIC MANGE ON THE RED FOX IN NEW YORK[1]

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Sarcoptic mange has been reported to infest the red fox in various states including Ohio (Olive and Riley, 1948), Pennsylvania (Pryor, 1956), New York (Stone et al., 1972) and Wisconsin (Trainer and Hale, 1969). Investigations have been primarily concerned with the occurrence and pathology of mange in the wild (Trainer and Hale, 1969) or its host specificity among related and unrelated genera (Stone et al., 1972). While transmission by bodily contact or environmental contamination is well known, little has been reported on the possible transmission through transfer of the causative agent, *Sarcoptes scabiei,* var. *canis,* by phoretic agents such as other ectoparasitic or free-living arthropods. In addition, few investigators have studied the density levels of *S. scabiei* var. *canis* on the red fox or their effect on indigenous populations of fox ectoparasites.

In October 1971, research was undertaken (Zeh, 1973) to investigate the ectoparasitic fauna of the red fox (*Vulpes fulva*) and gray fox (*Urocyon cinereoargenteus*). Seventy-five foxes from New York State, which were submitted to the Wildlife Research Laboratory at Delmar for necropsy, were examined for parasitic epifauna. The ectoparasitic groups recovered consisted of ticks, fleas, lice and mites.

Of 36 red foxes examined, 20 were found to be infested with *S. scabiei* var. *canis.* Square-centimeter sections of mangy epidermis from these specimens were placed in a potassium hydroxide solution for 24 hours to dissolve the epidermal tissue and facilitate determination of mite numbers.

Mite densities per square centimeter for four red foxes from Sullivan and Cayuga Counties were 1,054, 953, 1,017 and 1,877. In Great Britain, Burrows (1968) reported densities of up to 1,500 mites per square centimeter in sections of fox epidermis. In addition to those found in epidermal layers, countless mites could be seen crawling on the fur. Based on such densities, over-all mite infestations could range in the millions for one animal.

Sarcoptic mange mites have been found on flies for as long as 25 hours after feeding or laying eggs on the carcasses of mangy foxes and could act as transmitting agents of sarcoptic mange (Burrows, 1968). Mites, which are found in large numbers on fox fur, can also be seen crawling or attached to other ectoparasites that infest the fox. In the present study, sarcoptic mites were found on ixodid ticks in the areas of the scapulae and coxal spurs and on fleas under or attached to their body bristles. Considering the jumping mobility of fleas, one cannot discount the possibility of passive phoresy as a mechanism in the transmission of sarcoptic mange in a red fox population. Since many of these fleas show a preference for the Canidae, it would ensure transmission to canid hosts.

It is interesting to note that, while sarcoptic mange would appear to reduce the amount of optimum habitat for fox ectoparasites by scabbing and fur removal, it has little effect on epifaunal numbers. Of the 20 red foxes that exhibited sarcoptic mange, 14 had at least one other type of ectoparasite present and in large numbers. Sarcoptic mange did not inhibit infestations by fleas, lice or ticks. In many cases where scabbing and alopecia were evident, these parasites merely migrated to the more dorsal areas of the body where the fur and epidermis were still intact. Many mangy foxes had the highest numbers of ticks, lice and mites of all the foxes studied. Reduced scratching associated with debilitation caused by sarcoptic mange could account for the persistence of fleas, lice and ticks even though their optimum habitat was reduced.

Transmission of mange through the transfer of sarcoptic mange mites by fleas and other arthropod ectoparasites and the encouragement of infestations of such ectoparasites by debilitation of infected animals may contribute to the morbidity and moratitly of red foxes in New York.

[1]A contribution of Federal Aid in Fish and Wildlife Restoration Project W-35-R.

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AN ALBINO GRAY FOX[1]

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On October 30, 1972, a white male gray fox (*Urocyon cinereoargenteus*) was shot in the Town of New Scotland in Albany County and submitted to the Wildlife Research Laboratory at Delmar (N.Y.) by Cherokee Smith. Gross examination revealed a totally white coat and pink eyes, nose and foot pads The fox had a gross weight of 2,497 grams. External measurements in millimeters were: head, 147; tail, 349; hind foot, 134; ear from notch to tip, 60; total body length, 977. Necropsy revealed normal viscera with hemorrhaging due to the gunshot wound. The stomach contained corn and the remains of a cottontail rabbit. The fox's age was determined to be less than a year by microscopic examination of the cementum deposition on the root of the premolar. Histological examination of the iris of the eye showed an absence of pigment.

Albino gray fox from Albany County, New York.

[1]A contribution of the New York State Rabies Control Program and Federal Aid in Fish and Wildlife Restoration Project W-35-R. The authors wish to acknoledge data provided by Howard Parish, Cecil Barrett, Delmer Stalnaker, Elmer Davis, Stewart Van Wie, Ernest Saggese aand George Teidman, as well as the photograph by John W. Georg.

Although there have been reports of true albinism in some rodents (Benton 1953; Egoscue and Lewis, 1968; Hewiston, 1962) and carnivores including coyotes (Dellinger and Black, 1940; Green, 1947; Ozoga and Harger, 1966), there has been none for either the red fox or gray fox. Moreover, trappers under the New York State Rabies Control Progam have taken appoximately 40,000 foxes in the past 20 years without encountering an albino animal. However, two verbal reports of albino foxes have been made to personnel of the rabies control program. One pertained to an animal seen in Tompkins County in 1963 and the other to one seen in 1969 by Cherokee Smith in the Town of New Scotland in Albany County. Also, a largely-white gray fox observed near Mohawk in Herkimer County was photographed (Smith, 1969), but patches of pigmented hair were present. In any case, albinism in foxes in New York appears to be extremely rare.

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SINISTRALITY AND ALBINISM AMONG HOGCHOKERS IN THE HUDSON RIVER[1]

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Recent ecological studies in estuaries have provided additional information on the life history of, and the occurrence of abnormalities in, estuarine fishes. Dahlberg (1970) reported frequencies of injuries, and morphological and color anomalies, among 17 such species in Georgia. Color anomalies include staining, spotting and ambicoloration which vary among species and appear to be common among the Heterosomata (Hoese and Berglund, 1958; Dawson, 1962, 1967, 1969; Wilkens and Lewis, 1971). Dawson (1962) reviewed the literature on abnormal coloration in the Heterosomata. Albinism is uncommon, and partial albinism has been reported (Hoese and Berglund, 1958; Dawson, 1962, 1967, 1969; Moore and Posey, 1972) in four specimens of the hogchoker (*Trinectes maculatus*).

Moore and Posey (1972) found an almost completely albinistic hogchoker among approximately 18,000 specimens collected from the Patuxent River in Maryland. This specimen was also unusual because it was sinistral. They collected 10 other sinistral specimens that were otherwise normal. The sinistral hogchokers occurred at the rate of approximately one in 2,000 specimens from the Potomac and Patuxent Rivers in Maryland.

In a life history and ecological study of the hogchoker in the Hudson River in New York, one totally and two partially albinistic specimens were observed among some 3,000 individuals collected from 1969 through 1971. These three specimens appeared to be otherwise completely normal in their external morphology. The two partially albinistic individuals were 77 and 90 millimeters in total length and had some melanophores scattered over their bodies and clustered around the eyes. The melanophore arrangements were similar to those described by Hoese and Berglund (1958) and Moore and Posey (1972). The third albinistic specimen was 90 millimeters in total length and had no clusters of pigment, but some light-colored melanophores were scattered over the body (Figure 1). Three additional hogchokers (91, 113 and 121 millimeters in total length) exhibited complete reversal but no other external morphological abnormalities.

These frequencies of albinism and sinistrality in the hogchoker occurred at the rate of one in every 1,000, or about twice that in the Chesapeake area. These abnormalities may be induced genetically or epigenetically, or they may be caused by injury during early life stages (Dawson, 1967; Dalhberg, 1970). Houde (1971) found abnormalities in 26 juvenile lined sole (*Achirus lineatus*) among 31 specimens reared in the laboratory. He suggested that these conditions are not necessarily genetically controlled, but may be influenced by the environment. Greater environmental variability exists in the northern range of the hogchoker and may be related to the greater frequencies of sinistrality and albinism. The Hudson River appears to support the largest northern population of this species.

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[1]Contribution No. 77 of the Marine Research Laboratory, Noank, Conn. 06340. Specimens and data were collected while the author was employed by Raytheon Environmental Systems Center, Portsmouth, R.I. and Quirk, Lawler and Matusky Engineers, Tappan, N.Y. These two companies conducted ecological studies for electric power companies on the Hudson River. I am grateful to Lance L. Stewart and William A. Lund, Jr. of the Marine Research Laboratory for the photographs and review of this paper.

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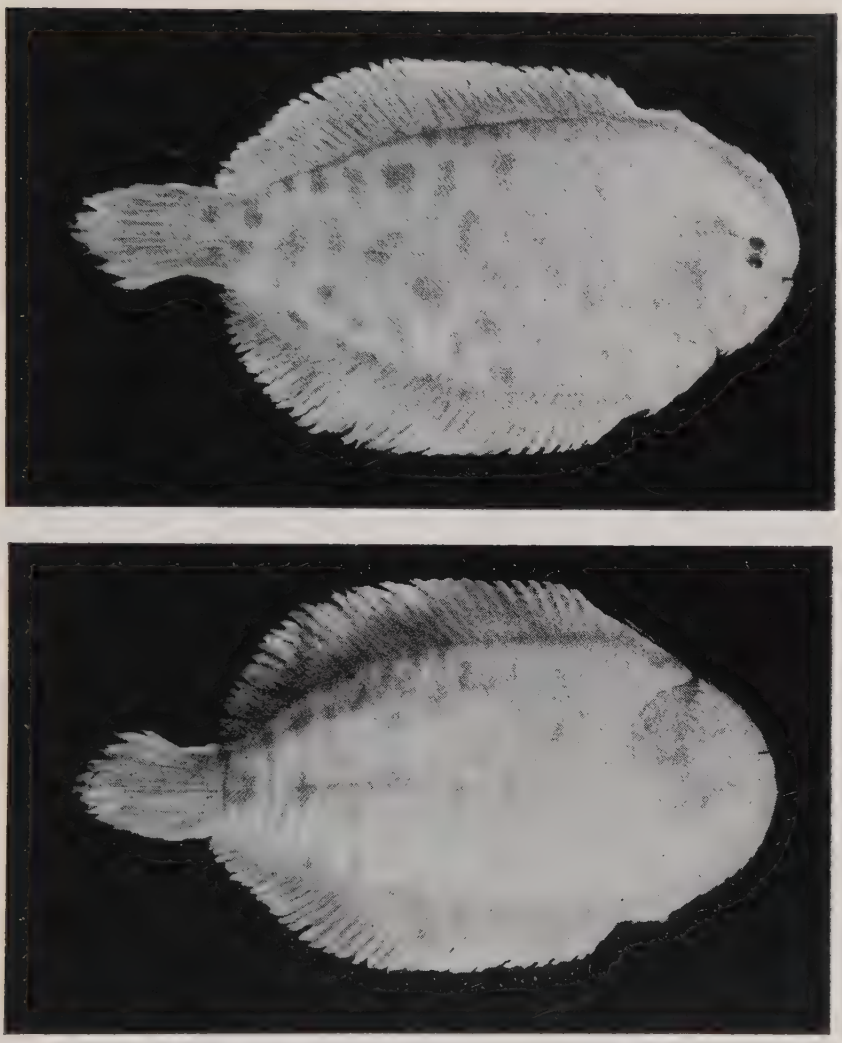

Figure 1. Dorsal (upper) and ventral (lower) views of almost totally albinistic hogchoker (90 millimeters in total length) from the Hudson River.

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PUGHEADEDNESS IN THE BLUEFISH[1]

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Pugheadedness has been reported for many species of teleost fishes (Dawson, 1964, 1966, 1971), but it has not been previously reported in the bluefish (*Pomatomus saltatrix*). Two such abnormal individiuals were captured in Long Island Sound (N.Y.). One (Figure 1, A), 3+ years of age with a weight of 2,670 grams and a fork length of 615 millimeters, was captured by hook and line in July 1971. The second (Figure 1, B), 4 years of age with a weight of 1,648 grams and a

Figure 1. Two pugheaded bluefish from Long Island Sound: (A) 3+ years old; (B) 4 years old.

fork length of 530 millimeters, was captured on August 6, 1971 by trap net. The length-weight-age statistics, when compared with those of Hamer (1959) and Backus (1962) indicate that Specimen A fell well within the limits for an age 3+ fish, while Specimen B was much smaller than a normal 4-year-old fish, being near the size of a 2- to 3-year-old individual. Gudger (1929) and Rose and Harris (1968) have suggested that a decreased size due to a reduced feeding efficiency may ensue as a result of the pugheaded condition. There was apparently no reduced feeding efficiency with Specimen A, while Specimen B may have encountered some difficulty in predation due to a slightly reduced upper jaw. Jaw reduction associated with pugheadedness has previously been reported by Mansueti (1958). Gudger (1930) stated that the external pugheaded appearance is partially due to the vertical downward bending of the frontal bones, as

[1] Contribution No. 24 of the New York Ocean Science Laboratory. The authors wish to acknowledge: the photography of Carl O. Mamay; the radiography of Ms. Shirley Hunt, laboratory X-ray technician of Radiological Health Services, P.C., East Hampton Medical Group, East Hampton, N.Y.; and David Greene and Philip Briggs of the New York Department of Environmental Conservation.

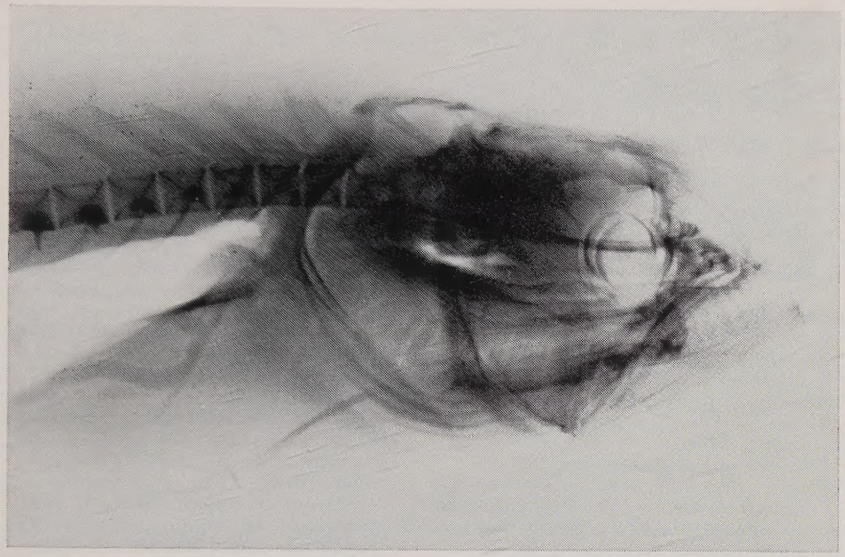

Figure 2. Radiograph of 3+-year-old pugheaded bluefish showing downward curvature of frontal bones resulting in an acutely steep forehead.

illustrated radiographically for Specimen A (Figure 2). Causes and effects of the pughead anomaly were discussed in detail by Hickey (1972, 1973).

It should be noted that, although pugheadedness has not previously been reported to occur in the bluefish, personal communications between the authors and both sport and commercial fishermen revealed that many such deformed bluefish have been caught in the past. Among fishermen this condition is termed "snub-nosed" or "pug-nosed".

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